**For use with List Numbers 12348 and 12618**

# Technical Service Manual

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Hospira

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# Contents

## Section 1


INTRODUCTION . . . . . 1-1
1.1 SCOPE . . . . . 1-1
1.2 CONVENTIONS . . . . . 1-2
1.3 COMPONENT DESIGNATORS . . . . . 1-2
1.4 ACRONYMS AND ABBREVIATIONS . . . . . 1-3
1.5 USER QUALIFICATION . . . . . 1-5
1.6 ARTIFACTS . . . . . 1-5
1.7 INSTRUMENT INSTALLATION PROCEDURE . . . . . 1-5
1.7.1 UNPACKING . . . . . 1-6
1.7.2 INSPECTION . . . . . 1-6
1.7.3 SELF TEST . . . . . 1-6
1.8 BIOMED SETTINGS . . . . . 1-8
1.8.1 IV PARAMETERS . . . . . 1-10
1.8.2 ALARMS LOG . . . . . 1-12
1.8.3 SETTING THE TIME AND DATE. . . . . 1-13


## Section 2


WARRANTY . . . . . 2-1


## Section 3


SYSTEM OPERATING MANUAL . . . . . 3-1


## Section 4


THEORY OF OPERATION . . . . . 4-1
4.1 GENERAL DESCRIPTION . . . . . 4-1
4.2 ELECTRONIC SUBSYSTEM OVERVIEW . . . . . 4-2
4.2.1 CPU SUBSYSTEM . . . . . 4-3
4.2.1.1 CPU . . . . . 4-3
4.2.1.2 SYSTEM MEMORY ADDRESS MAP . . . . . 4-3
4.2.1.3 PROGRAMMABLE READ-ONLY MEMORY . . . . . 4-4
4.2.1.4 STATIC RANDOM ACCESS MEMORY . . . . . 4-4
4.2.1.5 CONTROL LOGIC . . . . . 4-4
4.2.1.6 LCD CONTROLLER . . . . . 4-4
4.2.1.7 LCD BACKLIGHT CONTROL . . . . . 4-5
4.2.1.8 LCD CONTRAST CONTROL. . . . . 4-5
4.2.1.9 REAL-TIME CLOCK . . . . . 4-5
4.2.1.10 VOLTAGE MONITOR WATCHDOG TIMER . . . . . 4-6
4.2.1.11 ANALOG-TO-DIGITAL CONVERTER . . . . . 4-6
4.2.1.12 DIGITAL-TO-ANALOG CONVERTER . . . . . 4-8
4.2.1.13 FRONT PANEL KEYPAD MATRIX . . . . . 4-8
4.2.1.14 FRONT PANEL [ON/OFF] KEY . . . . . 4-8
4.2.1.15 FRONT PANEL LED INDICATORS . . . . . 4-8
4.2.1.16 KEYPAD LOCKOUT INTERFACE . . . . . 4-8
4.2.1.17 NURSE CALL INTERFACE . . . . . 4-9
4.2.1.18 AUDIBLE INDICATORS . . . . . 4-9
4.2.1.19 BARCODE READER INTERFACE . . . . . 4-9
4.2.1.20 DATAPORT INTERFACE . . . . . 4-10
4.2.1.21 POWER SUPPLY INTERFACE . . . . . 4-10
4.2.1.22 MECHANISM INTERFACE . . . . . 4-11

4.2.2 POWER SUPPLY SUBSYSTEM . . . . . 4-13
4.2.2.1 MAIN SWITCHING REGULATOR . . . . . 4-13
4.2.2.2 MAIN REGULATOR FAULT DETECTION . . . . . 4-14
4.2.2.3 SYSTEM POWER . . . . . 4-14
4.2.2.4 AUXILIARY SUPPLIES . . . . . 4-14
4.2.2.5 POWER CONTROL . . . . . 4-14
4.2.2.6 BATTERY VOLTAGE MEASUREMENT . . . . . 4-15
4.2.2.7 BATTERY CHARGE/DISCHARGE CURRENT MEASUREMENT . . . . . 4-15
4.2.2.8 BATTERY CHARGER . . . . . 4-16
4.2.3 MECHANISM SUBSYSTEM . . . . . 4-16
4.2.3.1 MOTORS/MOTOR DRIVE . . . . . 4-16
4.2.3.2 MOTOR POSITION SENSORS . . . . . 4-18
4.2.3.3 V2_5 REFERENCE VOLTAGE . . . . . 4-18
4.2.3.4 AIR SENSORS . . . . . 4-19
4.2.3.5 PRESSURE SENSORS . . . . . 4-20
4.2.3.6 PRESSURE SENSOR CALIBRATION . . . . . 4-22
4.2.3.7 CASSETTE TYPE/PRESENCE SELECTION . . . . . 4-22
4.2.3.8 SERIAL EEPROM . . . . . 4-22
4.3 PRINTED WIRING ASSEMBLIES . . . . . 4-23
4.3.1 POWER SUPPLY PWA. . . . . 4-23
4.3.2 PERIPHERAL PWA . . . . . 4-24
4.3.3 PERIPHERAL INTERFACE PWA . . . . . 4-24
4.3.4 CPU PWA . . . . . 4-25
4.3.5 DRIVER PWA . . . . . 4-25
4.3.6 SWITCH PWA . . . . . 4-26
4.3.7 APP PWA . . . . . 4-26
4.4 REMOTE MOUNTED PERIPHERALS . . . . . 4-27
4.4.1 LCD . . . . . 4-27
4.4.2 SEALED LEAD ACID BATTERY . . . . . 4-27
4.4.3 BARCODE READER WAND . . . . . 4-27
4.5 MECHANICAL OVERVIEW . . . . . 4-27
4.5.1 CASSETTE . . . . . 4-28
4.5.2 MECHANISM ASSEMBLY . . . . . 4-30
4.5.2.1 MOTOR AND VALVE ASSEMBLIES. . . . . 4-30
4.5.2.2 A/B VALVE SUBSYSTEM . . . . . 4-30
4.5.2.3 INLET/OUTLET VALVE SUBSYSTEM . . . . . 4-31
4.5.2.4 PLUNGER DRIVE SUBSYSTEM . . . . . 4-31

## Section 5

MAINTENANCE AND SERVICE TESTS . . . . . 5-1
5.1 ROUTINE MAINTENANCE . . . . . 5-1
5.1.1 CLEANING AND SANITIZING . . . . . 5-1
5.2 PERFORMANCE VERIFICATION TEST . . . . . 5-2
5.2.1 EQUIPMENT REQUIRED . . . . . 5-3
5.2.2 INSPECTION . . . . . 5-3
5.2.3 TEST SETUP . . . . . 5-4
5.2.4 SELF TEST . . . . . 5-4
5.2.5 CASSETTE ALARM TEST . . . . . 5-6
5.2.6 FREE FLOW TEST . . . . . 5-6
5.2.7 DISPLAY TEST . . . . . 5-6
5.2.8 KEYPAD VERIFICATION/FUNCTIONAL TEST . . . . . 5-7
5.2.9 ALARM LOUDNESS TEST . . . . . 5-8
5.2.10 LOCKOUT SWITCH TEST . . . . . 5-9

5.2.11 PROXIMAL OCCLUSION TEST . . . . . 5-9
5.2.12 PROXIMAL AIR-IN-LINE TEST . . . . . 5-10
5.2.13 DISTAL AIR-IN-LINE TEST. . . . . 5-11
5.2.14 DISTAL OCCLUSION TEST . . . . . 5-11
5.2.15 DELIVERY ACCURACY TEST . . . . . 5-13
5.2.16 NURSE CALL TEST . . . . . 5-14
5.2.17 ELECTRICAL SAFETY TEST . . . . . 5-14
5.2.18 END OF THE PVT . . . . . 5-15
5.5 PERIODIC MAINTENANCE INSPECTION . . . . . 5-15
5.6 BATTERY OPERATION OVERVIEW . . . . . 5-16

## Section 6

TROUBLESHOOTING . . . . . 6-1
6.1 TECHNICAL ASSISTANCE. . . . . 6-1
6.2 WARNING MESSAGES . . . . . 6-1
6.3 ALARM MESSAGES AND ERROR CODES . . . . . 6-2
6.3.1 OPERATIONAL ALARM MESSAGES . . . . . 6-2
6.3.2 ERROR CODES REQUIRING TECHNICAL SERVICE . . . . . 6-7
6.4 TROUBLESHOOTING PROCEDURES. . . . . 6-11

## Section 7

REPLACEABLE PARTS AND REPAIRS . . . . . 7-1
7.1 REPLACEABLE PARTS . . . . . 7-1
7.2 REPLACEMENT PROCEDURES . . . . . 7-1
7.2.1 SAFETY AND EQUIPMENT PRECAUTIONS . . . . . 7-1
7.2.2 REQUIRED TOOLS AND MATERIALS . . . . . 7-2
7.2.3 RUBBER FOOT PAD REPLACEMENT . . . . . 7-2
7.2.4 BATTERY, WIRE HARNESS, DOOR, AND DOOR PAD REPLACEMENT . . . . . 7-3
7.2.5 AC POWER CORD, RETAINER, AND VELCRO STRAP REPLACEMENT . . . . . 7-6
7.2.6 SEPARATING THE FRONT ENCLOSURE, REAR ENCLOSURE, AND MAIN CHASSIS ASSEMBLY . . . . . 7-7
7.2.7 PERIPHERAL INTERFACE ASSEMBLY REPLACEMENT . . . . . 7-9
7.2.8 PERIPHERAL PWA REPLACEMENT . . . . . 7-10
7.2.9 PERIPHERAL COMPONENT REPLACEMENT . . . . . 7-11
7.2.9.1 VOLUME CONTROL KNOB REPLACEMENT . . . . . 7-12
7.2.9.2 PERIPHERAL COVER REPLACEMENT . . . . . 7-12
7.2.10 FRONT/REAR ENCLOSURE GASKET REPLACEMENT . . . . . 7-15
7.2.11 LOWER FRONT ENCLOSURE GASKET REPLACEMENT . . . . . 7-15
7.2.11.1 EMI GASKET REPLACEMENT . . . . . 7-16
7.2.11.2 KEYPAD GASKET REPLACEMENT . . . . . 7-17
7.2.11.3 TOP SEAL GASKET REPLACEMENT . . . . . 7-17
7.2.12 REAR ENCLOSURE ASSEMBLY COMPONENT REPLACEMENT . . . 7-18
7.2.12.1 POLE CLAMP ASSEMBLY AND BACKING PLATE REPLACEMENT. . . . . 7-20
7.2.12.2 INTERNAL AC POWER CORD REPLACEMENT . . . . . 7-21
7.2.12.3 AC CONNECTOR REPLACEMENT . . . . . 7-21
7.2.12.4 FUSE REPLACEMENT . . . . . 7-22
7.2.12.5 REAR ENCLOSURE GASKET REPLACEMENT . . . . . 7-23
7.2.13 MINIPOLE ASSEMBLY REPLACEMENT . . . . . 7-23

7.2.14 MAIN CHASSIS ASSEMBLY COMPONENT REPLACEMENT . . . . 7-24
7.2.14.1 POWER SUPPLY PWA REPLACEMENT. . . . . 7-27
7.2.14.2 KEYPAD REPLACEMENT. . . . . 7-27
7.2.14.3 DISPLAY ASSEMBLY REPLACEMENT . . . . . 7-28
7.2.14.4 CPU/DRIVER CABLE REPLACEMENT . . . . . 7-29
7.2.14.5 MOTOR POWER CABLE REPLACEMENT. . . . . 7-32
7.2.14.6 CPU PWA REPLACEMENT . . . . . 7-32
7.2.14.7 PIEZO ALARM ASSEMBLY REPLACEMENT. . . . . 7-33
7.2.14.8 MECHANISM ASSEMBLY REPLACEMENT . . . . . 7-34
7.2.14.9 CASSETTE DOOR AND FLUID SHIELD REPLACEMENT . . 7-35
7.2.14.10 OPENER HANDLE ASSEMBLY REPLACEMENT . . . . . 7-38

## Section 8
SPECIFICATIONS . . . . . 8-1

## Section 9
DRAWINGS . . . . . 9-1

## Index . . . . . I-1

# Figures

Figure 1-1. Display and Keypad . . . . . 1-7
Figure 1-2. Biomed Settings . . . . . 1-9
Figure 1-3. IV Parameters. . . . . 1-10
Figure 1-4. Common IV Parameters . . . . . 1-11
Figure 1-5. Macro IV Parameters . . . . . 1-11
Figure 1-6. Alarms Log . . . . . 1-12
Figure 1-7. Setting the Time and Date . . . . . 1-13
Figure 4-1. Electronic Functional Diagram. . . . . 4-2
Figure 4-2. Serial Interface to ADC . . . . . 4-7
Figure 4-3. System Startup and Shutdown Timing, Battery Powered . . . . . 4-15
Figure 4-4. Stepper Motor Coils . . . . . 4-17
Figure 4-5. Air Sensor Block Diagram . . . . . 4-19
Figure 4-6. Pressure Sensor Excitation and Amplifier Block Diagram . . . . . 4-21
Figure 4-7. Major Elements of the Dual-Channel Cassette . . . . . 4-29
Figure 4-8. Fluid Path in the Cassette . . . . . 4-29
Figure 4-9. Mechanism Valve Pins and Sensor Locations . . . . . 4-31
Figure 5-1. Display and Keypad . . . . . 5-5
Figure 5-2. Primary Screen . . . . . 5-7
Figure 5-3. Rear View . . . . . 5-8
Figure 5-4. Special Cassettes with Bubble Sensor Tips Removed . . . . . 5-10
Figure 5-5. Distal Occlusion Test Setup . . . . . 5-12
Figure 7-1. Bottom View . . . . . 7-3
Figure 7-2. AC Power Cord Assembly and Battery Assembly . . . . . 7-5
Figure 7-3. Front Enclosures, Rear Enclosure, and Main Chassis . . . . . 7-8
Figure 7-4. Screw Placement Sequence . . . . . 7-9
Figure 7-5. Peripheral Interface Assembly and Peripheral PWAs. . . . . 7-11
Figure 7-6. Peripheral Interface Assembly Components . . . . . 7-14
Figure 7-7. Lower Front Enclosure Gaskets . . . . . 7-16
Figure 7-8. External Rear Enclosure Assembly Components . . . . . 7-18
Figure 7-9. Internal Rear Enclosure Assembly Components . . . . . 7-19
Figure 7-10. Minipole Assembly . . . . . 7-24

**Figure 7-11. Main Chassis Components (1 of 2) . . . 7-25**
**Figure 7-11. Main Chassis Components (2 of 2) . . . 7-26**
**Figure 7-12. CPU/Driver Cable Routing . . . 7-30**
**Figure 7-13. Ferrite Tape Positioning (1 of 2) . . . 7-31**
**Figure 7-13. Ferrite Tape Positioning (2 of 2) . . . 7-31**
**Figure 7-14. Fluid Shield Replacement . . . 7-36**
**Figure 7-15. Cassette Door and Opener Handle Assembly Replacement . . . 7-37**
**Figure 9-1. Illustrated Parts Breakdown (1 of 2) . . . 9-5**
**Figure 9-1. Illustrated Parts Breakdown (2 of 2) . . . 9-7**
**Figure 9-2. Front Enclosures, Rear Enclosure, and Main Chassis Assembly . . . 9-9**
**Figure 9-3. Front Enclosure Assemblies . . . 9-11**
**Figure 9-4. Rear Enclosure Assembly (1 of 2) . . . 9-13**
**Figure 9-4. Rear Enclosure Assembly (2 of 2) . . . 9-15**
**Figure 9-5. Peripheral Interface Assembly . . . 9-17**
**Figure 9-6. Main Chassis Assembly (1 of 2) . . . 9-19**
**Figure 9-6. Main Chassis Assembly (2 of 2) . . . 9-21**
**Figure 9-7. CPU PWA, Display, and Keypad . . . 9-23**
**Figure 9-8. CPU PWA and Main Chassis . . . 9-25**
**Figure 9-9. AC Power Cord, Retainer, Batteries, and Minipole . . . 9-27**
**Figure 9-10. Mechanism Assembly . . . 9-29**

# Tables

**Table 1-1. Conventions . . . 1-2**
**Table 1-2. System Configuration Data . . . 1-9**
**Table 4-1. Analog Inputs . . . 4-7**
**Table 4-2. Keypad Map . . . 4-8**
**Table 4-3. CPU-Power Supply Interface . . . 4-10**
**Table 4-4. CPU-Mechanism Interface Signals . . . 4-11**
**Table 4-5. Power Supply PWA Interface Connections . . . 4-23**
**Table 4-6. Peripheral PWA Interface Connections . . . 4-24**
**Table 4-7. Peripheral Interface PWA Interface Connections . . . 4-24**
**Table 4-8. CPU PWA Interface Connections . . . 4-25**
**Table 4-9. Driver PWA Interface Connections . . . 4-26**
**Table 4-10. APP PWA Interface Connections . . . 4-26**
**Table 5-1. Cleaning Solutions . . . 5-2**
**Table 5-2. Electrical Safety Measurements . . . 5-14**
**Table 6-1. Warning Messages . . . 6-2**
**Table 6-2. Operational Alarm Messages and Corrective Actions . . . 6-3**
**Table 6-3. Error Codes Requiring Technical Service . . . 6-7**
**Table 6-4. Troubleshooting with the PVT . . . 6-11**
**Table 9-1. Drawings . . . 9-1**
**Table 9-2. IPB for the Infuser . . . 9-2**

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## Section 1
# INTRODUCTION

The Plum A+®3 infusion system is designed to meet the growing demand for hospital wide device standardization, and serves a wide range of general floor and critical care needs. The infusion system consists of three component infusers, designated line 1, line 2, and line 3. By incorporating three lines into one unit, the Plum A+3 provides three primary lines, three secondary lines, and piggyback fluid delivery capabilities.

Compatibility with the LifeCare® 5000 PlumSet® administration sets and accessories makes the Plum A+3 a convenient and cost-effective infusion system.

## 1.1
## SCOPE

This manual is organized into the following sections:

- ❏ Section 1 Introduction
- ❏ Section 2 Warranty
- ❏ Section 3 System Operating Manual
- ❏ Section 4 Theory of Operation
- ❏ Section 5 Maintenance and Service Tests
- ❏ Section 6 Troubleshooting
- ❏ Section 7 Replaceable Parts and Repairs
- ❏ Section 8 Specifications
- ❏ Section 9 Drawings
- ❏ Appendix
- ❏ Index
- ❏ Technical Service Bulletins

If a problem in device operation cannot be resolved using the information in this manual, contact Hospira *(see Section 6.1)*.

Specific instructions for operating the device are contained in the *Plum A+® and Plum A+®3 System Operating Manual*.

**Note:** The terms “infusion system”, “infuser”, and “device” are used interchangeably throughout the manual.

**Note:** Figures are rendered as graphic representations to approximate actual product. Therefore, figures may not exactly reflect the product.

**Note:** Screen representations are examples only, and do not necessarily reflect the most current software version.

# 1.2 CONVENTIONS

The conventions listed in *Table 1-1* are used throughout this manual.

**Table 1-1. Conventions**

| Convention | Application | Example |
|---|---|---|
| *Italic* | Reference to a section, figure, table, or publication | *(see Section 6.1)* |
| **[ALL CAPS]** | In-text references to keys, touchswitches, and display messages | **[START]**<br><br>**CASSETTE TEST IN PROGRESS** |
| **Bold** | Emphasis | **CAUTION: Use proper ESD grounding techniques when handling components.** |
| | Screen displays | Select **Set Time and Date**. |

Throughout this manual, warnings, cautions, and notes are used to emphasize important information as follows:

**WARNING: A WARNING CONTAINS SPECIAL SAFETY EMPHASIS AND MUST BE OBSERVED AT ALL TIMES. FAILURE TO OBSERVE A WARNING MAY RESULT IN PATIENT INJURY AND BE LIFE-THREATENING.**

**CAUTION: A CAUTION usually appears in front of a procedure or statement. It contains information that could prevent hardware failure, irreversible damage to equipment, or loss of data.**

**Note:** A note highlights information that helps explain a concept or procedure.

# 1.3 COMPONENT DESIGNATORS

Components are indicated by alpha-numeric designators, as follows:

| | | | | | |
|---|---|---|---|---|---|
| Battery | **BT** | Diode | **D** | Resistor | **R** |
| Capacitor | **C** | Fuse | **F** | Switch | **SW** |
| Crystal | **Y** | Integrated Circuit | **U** | Transistor | **Q** |

The number following the letter is a unique value for each type of component (e.g., R1, R2).

**Note:** Alpha-numeric designators may be followed with a dash (-) number that indicates a pin number for that component. For example, U15-13 is pin 13 of the encoder chip [U15] on the interface PWA.

# 1.4
# ACRONYMS AND ABBREVIATIONS

Acronyms and abbreviations used in this manual are as follows:

| | |
|---|---|
| **A** | Ampere |
| **AC** | Alternating current |
| **A/D** | Analog-to-digital |
| **ADC** | Analog-to-digital converter |
| **APP** | Air, pressure, and pin |
| **BCR** | Barcode reader |
| **CCA** | Clinical care area |
| **CCFT** | Cold cathode fluorescent tube |
| **CMOS** | Complementary metal-oxide semiconductor |
| **CPU** | Central processing unit |
| **DAC** | Digital-to-analog converter |
| **DC** | Direct current |
| **DIP** | Dual in-line package |
| **DMA** | Direct memory access |
| **DMM** | Digital multimeter |
| **DPM** | Digital pressure meter |
| **ECG** | Electrocardiograph |
| **EEG** | Electroencephalogram |
| **EEPROM** | Electrically erasable/programmable read-only memory |
| **EMG** | Electromyogram |
| **EMI** | Electromagnetic interference |
| **ESD** | Electrostatic discharge |
| **ETO** | Ethylene oxide |
| **FPGA** | Field programmable gate array |
| **FSR** | Force sensing resistor |
| **hr** | Hour |
| **Hz** | Hertz |
| **ID** | Identification |
| **I/O** | Input/output |
| **IPB** | Illustrated parts breakdown |
| **IV** | Intravenous |
| **KB** | Kilobyte |
| **kHz** | Kilohertz |
| **KVO** | Keep vein open |
| **lbs** | Pounds |
| **LCD** | Liquid crystal display |

| | |
|---|---|
| **LED** | Light emitting diode |
| **L/S** | Line select |
| **MB** | Megabyte |
| **MHz** | Megahertz |
| **min** | Minute |
| **mL** | Milliliter |
| **mL/hr** | Milliliter per hour |
| **MMIO** | Memory-mapped input/output |
| **MOSFET** | Metal-oxide semiconductor field-effect transistor |
| **ms** | Millisecond |
| **nF** | nanofarad |
| **Op-amp** | Operational amplifier |
| **pF** | picofarad |
| **PROM** | Programmable read-only memory |
| **PVT** | Performance verification test |
| **PWA** | Printed wiring assembly |
| **PWM** | Pulse width modulator |
| **RAM** | Random-access memory |
| **rms** | Root-mean-square |
| **RTC** | Real-time clock |
| **SCC** | Serial communication controller |
| **SCP** | Serial communication port |
| **SMT** | Surface mount technology |
| **SPI** | Serial peripheral interface |
| **SRAM** | Static random access memory |
| **TQFP** | Thin quad flat pack |
| **V** | Volt |
| **$V_{AC}$** | Volts AC |
| **$V_{CC}$** | Collector supply voltage |
| **VCO** | Voltage-controlled oscillator |
| **$V_{DC}$** | Volts DC |
| **VSC** | 5 $V_{DC}$ supply circuitry |
| **VSO** | Voltage sweep oscillator |
| **VTBI** | Volume to be infused |
| **WDI** | Watchdog input |

# 1.5 USER QUALIFICATION

The Plum A+3 must be used at the direction of or under the supervision of licensed physicians or certified healthcare professionals who are trained in the use of the infusion system and the administration of parenteral and enteral fluids and drugs, and whole blood or red blood cell components. Training should emphasize preventing related IV complications, including appropriate precautions to prevent accidental infusion of air. The epidural route can be used to provide anesthesia or analgesia.

# 1.6 ARTIFACTS

Nonhazardous, low-level electrical potentials are commonly observed when fluids are administered using infusion devices. These potentials are well within accepted safety standards, but may create artifacts on voltage-sensing equipment such as ECG, EMG, and EEG machines. These artifacts vary at a rate that is associated with the infusion rate. If the monitoring machine is not operating correctly or has loose or defective connections to its sensing electrodes, these artifacts may be accentuated so as to simulate actual physiological signals.

To determine if the abnormality in the monitoring equipment is caused by the infuser instead of some other source in the environment, set the device so that it is temporarily not delivering fluid. Disappearance of the abnormality indicates that it was probably caused by electronic noise generated by the infuser. Proper setup and maintenance of the monitoring equipment should eliminate the artifact. Refer to the appropriate monitoring system documentation for setup and maintenance instructions.

# 1.7 INSTRUMENT INSTALLATION PROCEDURE

**CAUTION: Infusion system damage may occur unless proper care is exercised during product unpacking and installation.**

**CAUTION: Infusion system performance may be degraded by electromagnetic interference (EMI) from devices such as electrosurgical units, cellular phones, and two-way radios. Operation of the infusion system under such conditions should be avoided.**

Accessory equipment connected to the analog and digital interfaces must be certified according to the respective IEC standards (e.g., IEC 60601-1 for medical equipment). Furthermore, all configurations shall comply with the system standard IEC 60601-1-1. Any person who connects additional equipment to the signal input or output part is configuring a medical system, and is therefore responsible for ensuring that the system complies with the requirements of IEC 60601-1-1. If in doubt, contact Hospira.

The instrument installation procedure consists of unpacking, inspection, and self test.

## 1.7.1
# UNPACKING

Inspect the shipping container as detailed in *Section 1.7.2*. Use care when unpacking the infusion system. Retain the packing slip and save all packing material in the event it is necessary to return the infuser to the factory. Verify the shipping container contains a copy of the system operating manual.

## 1.7.2
# INSPECTION

Inspect the shipping container for damage. Should any damage be found, contact the delivering carrier immediately.

**CAUTION: Inspect the infuser for evidence of damage. Do not use the device if it appears to be damaged. Should damage be found, contact Hospira *(see Section 6.1)*.**

Inspect the infusion system periodically for signs of defects such as worn accessories, broken connections, or damaged cable assemblies. Also inspect the infuser after repair or during cleaning. Replace any damaged or defective external parts.

## 1.7.3
# SELF TEST

When performing the self test, line 1, line 2, and line 3 must be tested. However, if appropriate, the test may be performed on all lines concurrently.

**CAUTION: Do not place the infuser in service if the self test fails.**

If an alarm condition occurs during the self test, cycle the power and repeat the self test. If the alarm condition recurs, note the message and take corrective action *(see Section 6)*. Repeat the self test. If the alarm condition continues to recur, remove the infuser from service and contact Hospira.

> **Note:** Do not place the infuser in service if the battery is not fully charged. To make certain the battery is fully charged, connect the infuser to AC power for six hours *(see Section 8)*.

> **Note:** Records prior to the date the infuser is received may be from the manufacturing process. Disregard any events from dates prior to receipt of the infuser.

To perform the self test, see *Figure 1-1*, and proceed as follows:

1. Connect the AC power cord to a grounded AC outlet. Verify the **Charge/Line** indicator **CHARGE** illuminates and an alarm tone sounds.
2. Without a cassette installed, press **[ON/OFF]** to turn on the infuser.
3. The LCD screen briefly displays the **SELF TEST** screen *(see Figure 1-1)*. If the **SELF TEST** screen does not appear, contact Hospira.
4. After the self test is complete, the message **INSERT PLUM SET CLOSE LEVER** appears.
5. Verify the time and date. To set the time and date, see *Section 1.8.3*.
6. Open the cassette door and insert a primed cassette. Close the cassette door. The cassette test is complete when the **CASSETTE TEST IN PROGRESS** message disappears.

**Note:** The message **MECHANISM INITIALIZATION IN PROGRESS** may briefly appear prior to the **CASSETTE TEST IN PROGRESS** message.

7. The **CLEAR SETTINGS?** message may appear. Press the **[YES]** softkey.
8. Press **[ON/OFF]** to turn off the infuser.

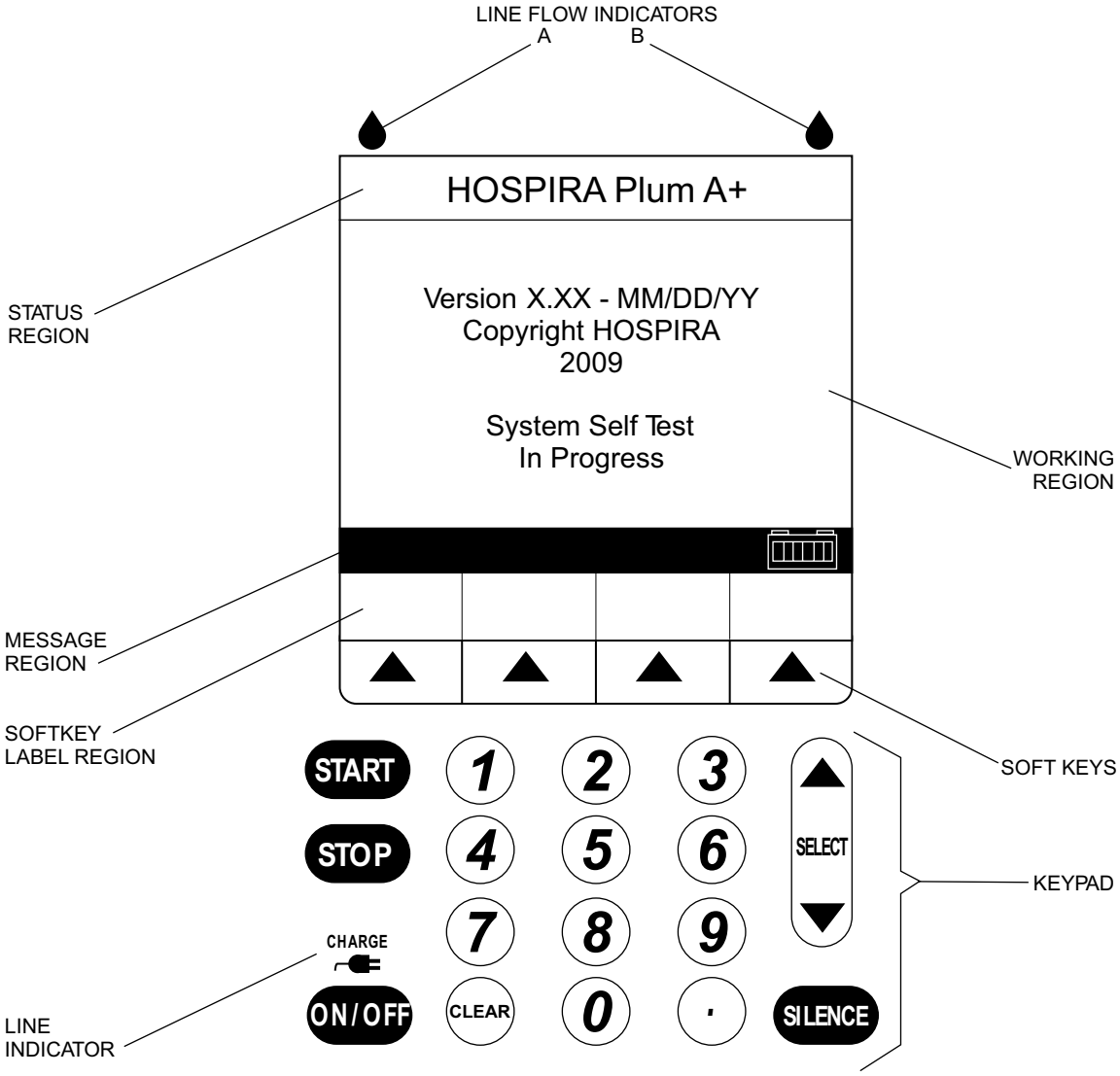


**Figure 1-1. Display and Keypad**

# 1.8
# BIOMED SETTINGS

The **BIOMED SETTINGS** screens contain the following options that can be changed or reviewed by qualified personnel:

- IV screen parameters
- Alarms log
- Set time and date

All infusers (new or refurbished) are shipped with factory settings *(see Table 1-2)*.

**Note:** Biomed screens do not time out for the **Infuser Idle** alarm or **No Action** alarm.

**Note:** The battery will not be detected in the Biomed service mode.

To access the Biomed settings, proceed as follows:

1. Open the door and turn on the device. The infusion system will perform a self test.
2. After the self test is complete, the message **INSERT PLUM SET CLOSE LEVER** appears.
3. Press the decimal [**.**] key, then **[START]**, and verify the **BIOMED SETTINGS** screen is displayed *(see Figure 1-2)*.

   **Note:** The **BIOMED SETTINGS** screen may display **[CHANGE BATTERY]**. The **[CHANGE BATTERY]** softkey does not appear on earlier versions of the Plum A+3.

| Table 1-2. System Configuration Data | | |
|---|---|---|
| **Data** | **Options Range** | **Factory Setting** |
| Maximum macro IV mode delivery rate | 0.1 - 99.9 mL/hr<br>and 100 - 999 mL/hr | 999 mL/hr |
| Macro distal occlusion alarm<br>(pressure level) | 1 to 15 psi | 6 psi |
| Deliver together enable | Concurrent or Piggyback | Piggyback |
| Delayed start/standby enable | Yes or No | Yes |
| Continue rate | Rate or KVO | KVO |
| Nurse callback default | Yes or No | No |
| Time | (24 hr) 00:00 - 23:59 in<br>one minute increments | Factory time |
| Date | 1/1/2002 - 12/31/2098 | Factory date |

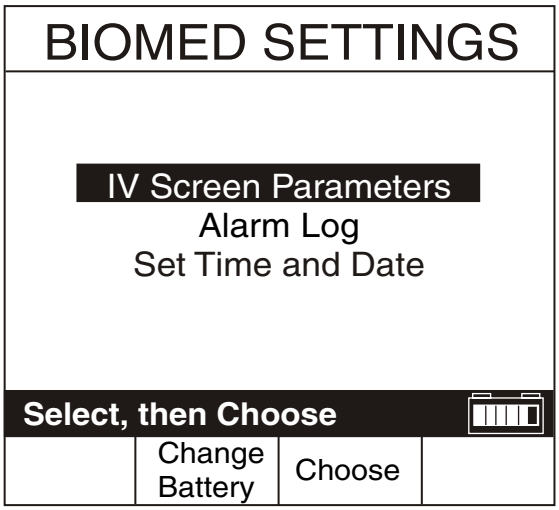


**Figure 1-2. Biomed Settings**

## 1.8.1
# IV PARAMETERS

The **IV Parameters** screen contains Common IV Parameters and Macro IV Parameters *(see Figure 1-3)*.

To change the IV parameters see *Figure 1-4* and *Figure 1-5*, then proceed as follows:

1. Access the **BIOMED SETTINGS** screen as described in *Section 1.8*.
2. Select **IV Screen Parameters**, and press **[CHOOSE]**.
3. Select the parameters to be changed, and press **[CHOOSE]**.
4. Using the **[CHANGE VALUE]** softkey, select the desired value, and press **[ENTER]**.
5. Repeat step 3 and step 4 for each parameter to be changed.
6. If there are no other changes, turn off the infuser.

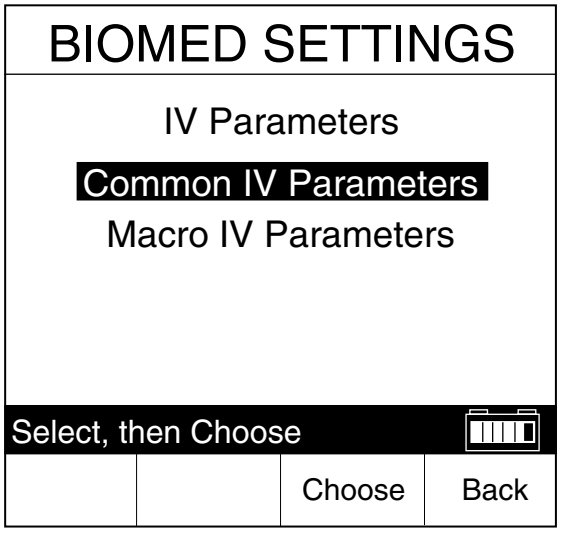


**Figure 1-3. IV Parameters**

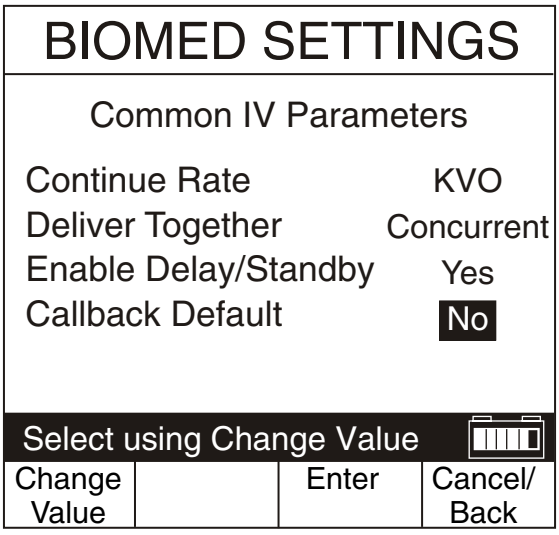


**Figure 1-4. Common IV Parameters**

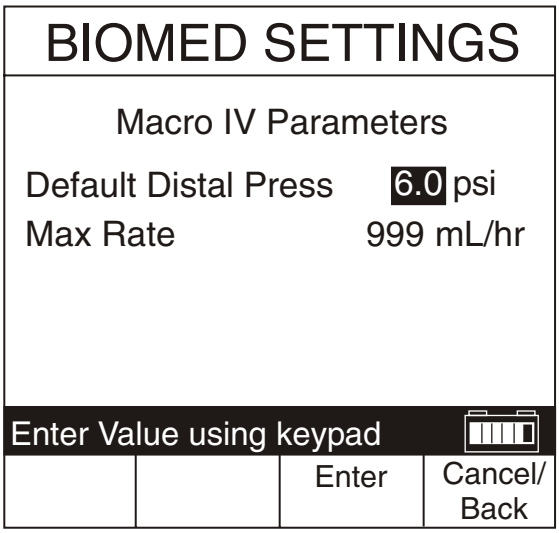


**Figure 1-5. Macro IV Parameters**

## 1.8.2
# ALARMS LOG

The Alarms Log will retain the latest 40 alarm and malfunction codes, listed in order from the most current to the oldest.

To view the Alarms Log see *Figure 1-6*, then proceed as follows:

1. Access the **BIOMED SETTINGS** screen as described in *Section 1.8*.
2. Select **Alarms Log**, and press **[CHOOSE]**. Use the **[PAGE UP]** and **[PAGE DOWN]** softkeys to view the Alarms Log.
3. Press **[BACK]** to exit the Alarms Log and return to the main **BIOMED SETTINGS** screen.

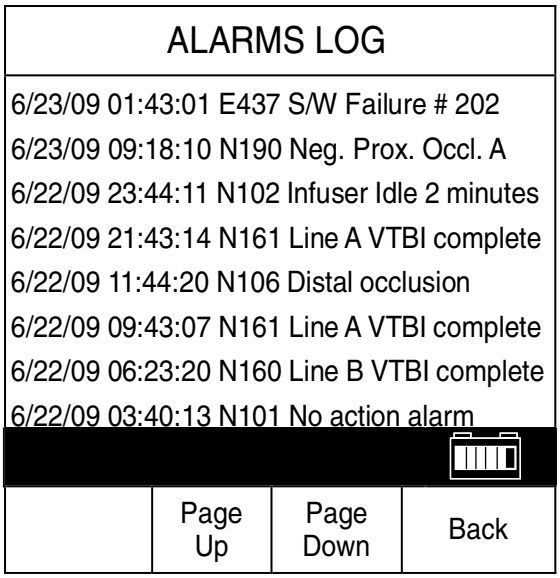
ALARMS LOG
6/23/09 01:43:01 E437 S/W Failure # 202
6/23/09 09:18:10 N190 Neg. Prox. Occl. A
6/22/09 23:44:11 N102 Infuser Idle 2 minutes
6/22/09 21:43:14 N161 Line A VTBI complete
6/22/09 11:44:20 N106 Distal occlusion
6/22/09 09:43:07 N161 Line A VTBI complete
6/22/09 06:23:20 N160 Line B VTBI complete
6/22/09 03:40:13 N101 No action alarm
Page Up
Page Down
Back

**Figure 1-6. Alarms Log**

## 1.8.3
# SETTING THE TIME AND DATE

**Note:** The infusion system will automatically display February 29 on leap year.

**Note:** Daylight savings and time zone changes must be made manually.

To set the time and date, see *Figure 1-7*, then proceed as follows:

1. Access the **BIOMED SETTINGS** screen as described in *Section 1.8*.
2. Select **Set Time and Date**, and press **[CHOOSE]**.
3. Select the parameter to be changed, then enter the desired value.
4. Verify the time and date are correct, then press **[ENTER]** to return to the **BIOMED SETTINGS** screen.
5. If there are no other changes, turn off the infuser.

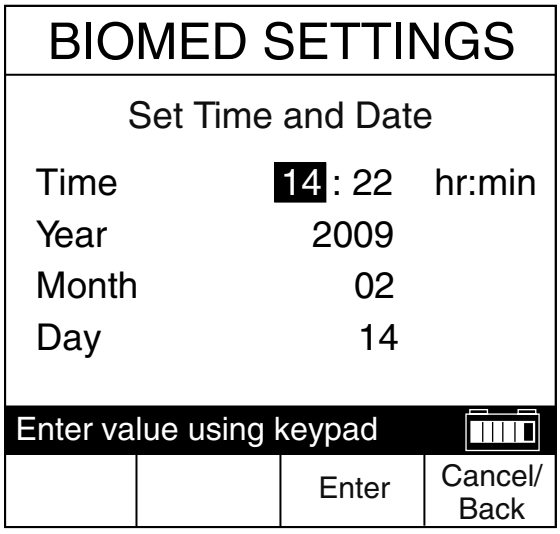


**Figure 1-7. Setting the Time and Date**

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## Section 2

# WARRANTY

Subject to the terms and conditions herein, Hospira, Inc., hereinafter referred to as Hospira, warrants that (a) the product shall conform to Hospira's standard specifications and be free from defects in material and workmanship under normal use and service for a period of one year after purchase, and (b) the replaceable battery shall be free from defects in material and workmanship under normal use and service for a period of 90 days after purchase. Hospira makes no other warranties, express or implied, and specifically disclaims the implied warranties of merchantability and fitness for a particular purpose.

Purchaser's exclusive remedy shall be, at Hospira's option, the repair or replacement of the product. In no event shall Hospira's liability arising out of any cause whatsoever (whether such cause be based in contract, negligence, strict liability, other tort, or otherwise) exceed the price of such product, and in no event shall Hospira be liable for incidental, consequential, or special damages or losses or for lost business, revenues, or profits. Warranty product returned to Hospira must be properly packaged and sent freight prepaid.

The foregoing warranty shall be void in the event the product has been misused, damaged, altered, or used other than in accordance with product manuals so as, in Hospira's judgment, to affect its stability or reliability, or in the event the serial or lot number has been altered, effaced, or removed.

The foregoing warranty shall also be void in the event any person, including the Purchaser, performs or attempts to perform any major repair or other service on the product without having been trained by an authorized representative of Hospira and using Hospira documentation and approved spare parts. For purposes of the preceding sentence, "major repair or other service" means any repair or service other than the replacement of accessory items such as batteries and detachable AC power cords.

In providing any parts for repair or service of the product, Hospira shall have no responsibility or liability for the actions or inactions of the person performing such repair or service, regardless of whether such person has been trained to perform such repair or service. It is understood and acknowledged that any person other than a Hospira representative performing repair or service is not an authorized agent of Hospira.

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## Section 3

# SYSTEM OPERATING MANUAL

A copy of the System Operating Manual is included with every Plum A+3 infusion system. If a copy is not available, contact Hospira *(see Section 6.1)*.

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Section 4

# THEORY OF OPERATION

This section describes the Plum A+3 theory of operation. The theory of operation details the general description, electronic subsystem overview, printed wiring assemblies, remote mounted peripherals, and mechanical overview of the infusion system.

## 4.1 GENERAL DESCRIPTION

The infusion system includes the following features:

- Dose calculation
- Loading dose
- Multistep programming
- Therapy selection
- Nurse call
- Delayed Start setting
- Standby mode
- Drug Library
- Piggyback/concurrent delivery modes
- Titration
- 0.1-99.9 mL/hr flow rate range for both lines (in 0.1 mL/hr increments)
- 100-999 mL/hr flow rate range for both lines (in 1 mL/hr increments)
- Anti free-flow protection
- Air removal/backpriming
- Battery gauge
- Air detection (proximal/distal)
- Serial communication
- Alarm history
- Volumes infused (A, B, total volumes)
- KVO at dose end (1 mL/hr or less depending on delivery rate) or Continue Rate to continue
- Variable distal pressure setting
- Nonpulsatile volumetric accuracy
- Microprocessor control
- Large LCD
- Panel back illumination on mains power
- Lockout switch
- Standard fullfill, partfill, syringe, and vial use
- Enteral and parenteral fluid delivery
- Blood and blood product delivery

Alarms include the following:

- Distal Occlusion
- Proximal Occlusion
- Distal Air-in-Line
- Proximal Air-in-Line
- Low Battery
- Door Opened While Pumping
- Lockout Violation
- VTBI Complete
- Valve/Cassette Test Failure
- Nurse Call
- No Action
- Infuser Idle for Two Minutes

# 4.2
# ELECTRONIC SUBSYSTEM OVERVIEW

This section describes the function and electronic circuitry of the following three main subsystems in the infusion system: CPU subsystem, power supply subsystem, and mechanism subsystem *(see Figure 4-1)*.

**Note:** An asterisk (*) denotes an active low or negative true logic signal.

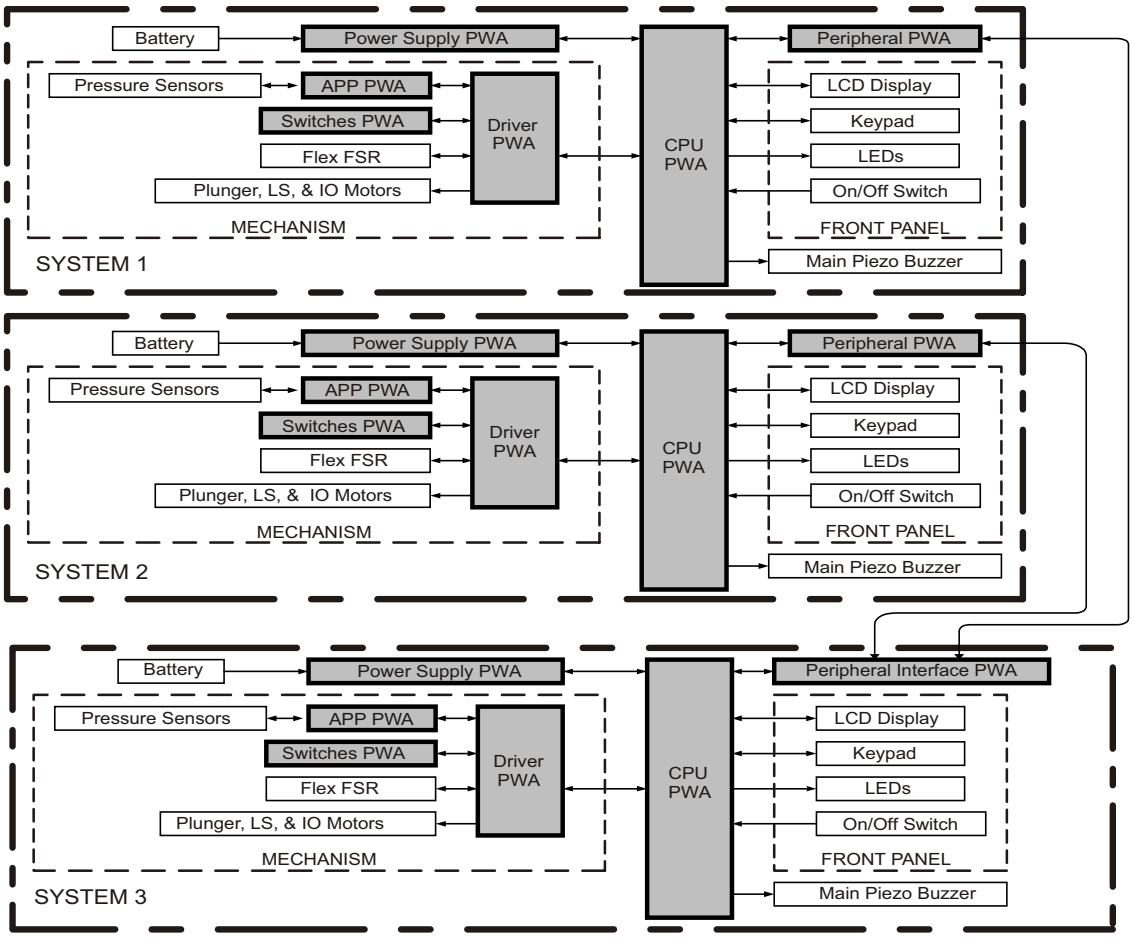


**Figure 4-1. Electronic Functional Diagram**

## 4.2.1
# CPU SUBSYSTEM

The CPU subsystem contains the main microcontroller that is responsible for controlling the display/keyboard interface, external communications interfaces, barcode reader (BCR) interface, and system management.

The CPU subsystem provides the following functions:

- External memory devices access
- LCD interfaces
- Real-time clock generator interface
- System watchdog
- Analog-to-digital and digital-to-analog converter interface
- Keypad interfaces
- Control and monitor status signals, such as LEDs, audible alarms, volume control, nurse call switch, and lockout switch
- Serial communication with host computer (DataPort) and barcode reader
- Power supply subsystem interface
- Mechanism subsystem interface

### 4.2.1.1
## CPU

The central processing unit is a Motorola MC68302 CPU. The CPU has a closely coupled 16 bit data bus and 24 bit address bus, MC68000 microprocessor core, a system integration block for peripherals, and an RISC communications processor. The MC68302 is packaged in a 144 pin thin quad flat pack (TQFP) package and operates from a 3.3 $V_{DC}$ power supply.

The on-chip peripheral devices are isolated from the system through the dual port RAM. The 1152 byte dual port RAM has 576 bytes of system RAM and 576 bytes of parameter RAM that contains various peripheral registers, parameters, and the buffer descriptors for each of the three serial communication controller (SCC) channels and the serial communication port (SCP) channels. The 24 bit address bus is capable of accessing up to 16 MB of data.

### 4.2.1.2
## SYSTEM MEMORY ADDRESS MAP

The CPU has a 24 bit address bus when combined with UDS*/A0. The address bus is a bi-directional, three state bus capable of addressing 16 MB of data that is configured as 16 bits per word (including the IMP internal address space). Each of the four programmable chip-select lines has two registers that define the starting address of a particular address space and the block size.

#### 4.2.1.3
## PROGRAMMABLE READ-ONLY MEMORY

The CPU subsystem has two 512 K x 8 bit programmable read-only memory (PROM) memory devices that provide a total of 1024 KB. The PROM space is expandable up to 2 MB. The PROM memory devices operate off the 3.3 $V_{DC}$ supply. The CPU chip-select 0 pin (CS0*), is connected to the PROM chip-enable (CE*) pin (signal CSROM*). This special chip-select signal can support bootstrap operation after reset.

The interface to the CPU is the 16 bit data bus, and a 19 bit address bus. The address bus is connected to the ADDR<19:1> lines, and the data bus is connected to the DATA<15:0> lines.

#### 4.2.1.4
## STATIC RANDOM ACCESS MEMORY

There are two 512 K x 8 bit CMOS static random access memory (SRAM) devices that provide a total of 1024 KB of data memory. During an SRAM read or write cycle, the chip-enable (CE*) is controlled by the CPU chip-select pin 1 (CS1*, signal name (CSRAM*)). The SRAM space is expandable up to 2 MB. The SRAM operates off the 3.3 $V_{DC}$ supply. The CPU subsystem includes the additional SRAM for video buffer and real-time clock.

#### 4.2.1.5
## CONTROL LOGIC

The CPU PWA uses field programmable gate arrays (FPGA) that are high density, high speed, I/O intensive general purpose devices. They are used to implement all digital control functions, including memory-map address decoding, memory read-write enable, direct memory access (DMA) request, I/O status signals, chip-select control, motor control, sensor select, and power up/system reset control.

#### 4.2.1.6
## LCD CONTROLLER

The liquid crystal display (LCD) controller is used to interface the LCD to the CPU. The device displays layered text and graphics, scrolls the display in any direction, and partitions the display into multiple screens. It stores bit-mapped graphic data in ‘external frame buffer memory. The display controller functions include transferring data from the controlling microprocessor to the buffer memory, reading memory data, converting data to display pixels, and generating timing signals for the buffer memory and LCD panel. The LCD controller accesses 32 KB of frame buffer SRAM (video) via the controller’s video address and data busses (VA<14:0> and VD<7:0>). The LCD controller external clock frequency is 8 MHz. The LCD controller and the display memory are operated off the 3.3 $V_{DC}$ supply. The output signal levels are shifted up to 5 $V_{DC}$ by buffers for interface with the 5 $V_{DC}$ LCD panel.

The interface to the CPU is through the lower 8 bits of the data bus that is connected to DATA<7:0> lines, address line A1, and LCD chip-select signal CSLCD* (CS2*). This controller is also configured as 8080 family compatible interface device with all the control signals, such as WRLCD* (WR*) and RDLCD* (RD*), generated by the FPGA logic.

### 4.2.1.7
## LCD BACKLIGHT CONTROL

The LCD panel is backlit by a cold cathode fluorescent tube (CCFT) lamp. The CCFT lamp requires 300 $V_{rms}$ to operate; a current controlled DC-to-AC voltage inverter circuit is used to deliver a current regulated sine wave to the lamp. A switching regulator regulates the CCFT current by monitoring feedback pin 3, and varies its output duty cycle to drive a DC/AC inverter. Intensity control is achieved by superimposing a DC control signal with the feedback signal. The DC control signal is sourced by a voltage divider consisting of a digitally controlled non-volatile potentiometer and three series diodes.

The CPU can adjust LCD backlight intensity by selecting the digitally controlled non-volatile potentiometer and controlling TUBU/D and TUBINC* signals. The potentiometer has a five bit up/down counter with non-volatile memory. It is used to store one of 31 settings of the potentiometer. Each count represents 323 Ωwith a range of 323 to 10 KΩ The current counter value is stored in non-volatile memory after CSTUB* is returned high while the TUBINC* input is also high. The current counter value is not stored if CSTUB* is returned high and TUBINC* is low. The CCFT intensity is directly proportional to the CCFT current, where 0 $mA_{rms}$ is minimum intensity and 5 $mA_{rms}$ is maximum intensity. The CCFT current is inversely proportional to the counter value.

### 4.2.1.8
## LCD CONTRAST CONTROL

A digitally adjustable LCD bias supply is used to control the LCD contrast over a range of -24 to -8 $V_{DC}$. It is digitally adjustable in 64 equal steps by an internal digital-to-analog converter (DAC). The CPU provides two signals, LCDADJ (ADJ) and LCDCTL (CTL), to interface with this device. On power up or after a reset, the counter sets the DAC output to the mid-range value. Each rising edge of LCDADJ increments the DAC output. When incremented beyond full scale, the counter rolls over and sets the DAC to the minimum value. Therefore, a single pulse applied to LCDADJ increases the DAC set point by one step, and 63 pulses decrease the set point by one step.

### 4.2.1.9
## REAL-TIME CLOCK

The watchdog timekeeper chip includes a complete real-time clock/calendar (RTC), watchdog timer, alarm, and interval timer. The time/date information includes hundredths of seconds, seconds, minutes, hours, date, month, and year. The date at the end of the month is automatically adjusted for months with less than 31 days, including correction for leap year. The watchdog timekeeper operates in either 24-hour or 12-hour format with an AM/PM indicator. The device can be programmed to set up an interval timer, and it can generate an alarm every day, hour, or minute. These alarm functions may be used to schedule real-time related activities. A parallel resonant 32.768 kHz crystal oscillator drives the internal time base.

The external interface is a separate (non-multiplexed) 8 bit data bus and 6 bit address bus, with a contiguous address space of 64 bytes. When system power is turned off, a battery voltage input is available that makes the RTC data non-volatile. The address bus is connected to the ADDR<6:1> lines, and the data bus is connected to DATA<7:0> lines. Since the CPU accesses are 16 bits wide, the RTC data is on the lower byte of the word. The RTC chip-enable pin (CE*) is active low enabled for read and write operations. It is driven by the FPGA control logic, chip-select RTC signal (CSRTC*) that involves address decoding circuitry.

#### 4.2.1.10
## VOLTAGE MONITOR WATCHDOG TIMER

It is important to protect the system during power transitions, and the CPU is reset after the $V_{CC}$ power supply is applied. The microprocessor supervisory circuit generates an automatic reset output during power up, power down, or brownout conditions. When the $V_{CC}$ falls below the reset threshold voltage of 2.9 $V_{DC}$, the reset signal (RESET*) goes low and holds the microprocessor in reset for approximately 200 ms after $V_{CC}$ rises above the threshold. The supervisory circuit includes a chip-select inhibit circuit that is used to disable access to the real-time clock's non-volatile SRAM during power transitions and power down mode.

This device also provides a watchdog timer function to monitor the activity of the microprocessor. To service the watchdog timer immediately after reset, the device has a longer time-out period (1.6 second minimum) right after a reset. The normal time-out period (70 ms minimum) is effective after the first transition of watchdog input (WDI) after RESET* is inactive. If the microprocessor does not toggle WDI within the time-out period, both RESET* and watchdog out (WDO*) outputs are asserted low. The RESET* remains active low for a minimum of 140 ms and it resets the CPU. The WDO* remains low as long as the WDI remains either high or low for longer than the watchdog time-out period. After a reset, the software reads this memory-mapped bit to determine if the latest reset was a watchdog time-out.

#### 4.2.1.11
## ANALOG-TO-DIGITAL CONVERTER

The analog-to-digital converter (ADC) monitors the proximal pressure sensor, distal pressure sensor, proximal air sensor, distal air sensor, battery charge/discharge current, battery voltage, buzzer test signal, LCD contrast voltage, CCFT test signal, and two chopper motor drive reference voltages. The ADC is an advanced 10 bit accurate, 11 channel, switched-capacitor, successive-approximation device. It has three inputs and a three-state output (chip-select, I/O clock, address input, and data out) that provide a direct four-wire interface to the serial communication port of the CPU. The ADC is designed to be used in conjunction with multiple serial devices on a common bus; consequently, the data-out pin is driven only when the chip-select (CS*) pin is asserted. *Figure 4-2* illustrates the serial interface between the ADC and the CPU.

In addition to a high-speed ADC and versatile control capability, this device has an on-chip 14 channel multiplexer that can select any one of 11 analog inputs or any one of three internal self test voltages. The sample-and-hold function is automatic. The end-of-conversion (EOC) output goes high to indicate that conversion is complete. The CPU polls the EOC signal.

Channel selection and conversion results are transferred through the SCP pins. A serial transfer synchronizing clock (SPCLK) must be fed into the I/O clock input pin when the CS* pin is driven low. The address to be converted is serially transmitted into the address pin, and the conversion results are serially shifted out the data-out pin. Typical access time is 21 µsec. The APP PWA is the source of the 2.5 $V_{DC}$ reference voltage. The analog inputs are selected by the channel multiplexer according to the input address *(see Table 4-1)*. The input multiplexer is a break-before-make type to reduce input-to-input noise injection resulting from channel switching.

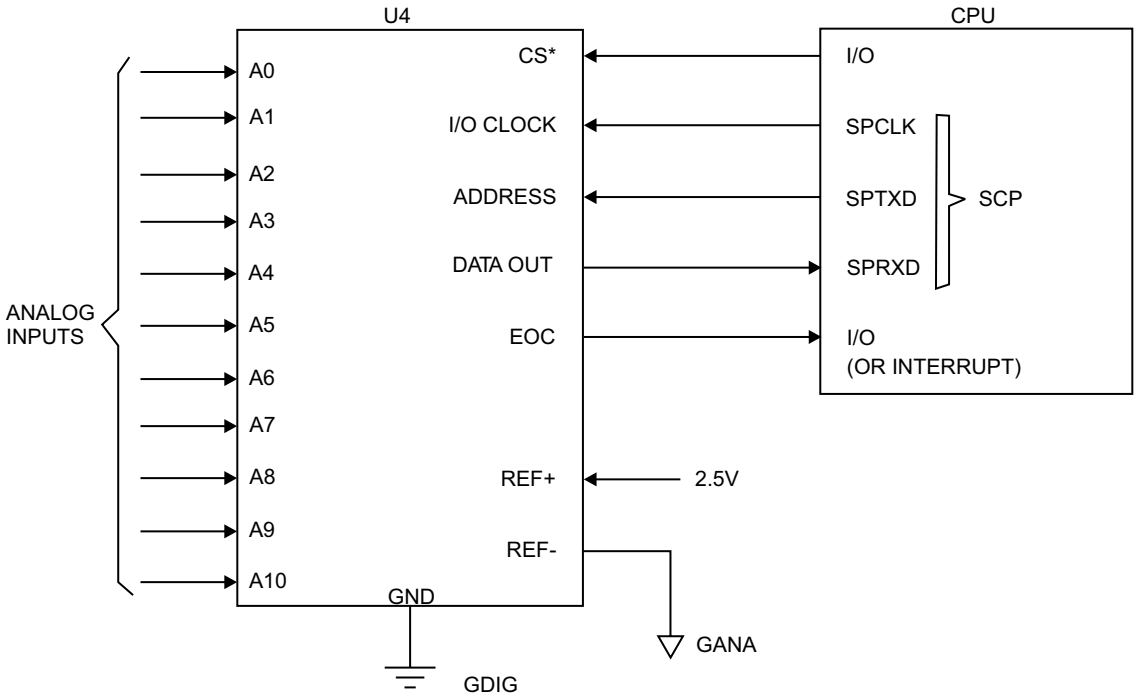


**Figure 4-2. Serial Interface to ADC**

**Table 4-1. Analog Inputs**

| Signal Name | Analog Input | Address (hex) | Description |
|---|---|---|---|
| PRPRS | A0 | $00 | Proximal pressure sensor |
| DIPRS | A1 | $01 | Distal pressure sensor |
| PXAIR | A2 | $02 | Proximal air sensor |
| DIAIR | A3 | $03 | Distal air sensor |
| IBATT | A4 | $04 | Battery current |
| VBATT | A5 | $05 | Battery voltage |
| BUZTST | A6 | $06 | Buzzer test voltage |
| LCDTST | A7 | $07 | LCD contrast test voltage |
| TUBTST | A8 | $08 | CCFT intensity test voltage |
| MI_STA | A9 | $09 | Motor current A control |
| MI_STB | A10 | $0A | Motor current B control |
| | | $0B | $(V_{ref(+)} - V_{ref(-)}) / 2$ |
| | | $0C | $V_{ref(-)}$ |
| | | $0D | $V_{ref(+)}$ |

#### 4.2.1.12
## DIGITAL-TO-ANALOG CONVERTER

The dual 8 bit digital-to-analog converter (DAC) generates two analog signals to control the phase A and phase B motor coil currents. The interface between the DAC device and the CPU is the 8 bit data bus that is connected to DATA15:8. All the control signals for this DAC are generated by FPGA logic devices. Buffer amplifier/ground compensation circuits condition the DAC outputs.

#### 4.2.1.13
## FRONT PANEL KEYPAD MATRIX

A 5 x 5 membrane switch keypad matrix is located on the front panel. The keypad column lines (COL4:0) are driven by open collector type memory mapped input ports, while the keypad row lines (ROW4:0), are read by memory mapped input ports *(see Table 4-2)*. The keypad strobing, scanning, and switch de-bouncing is accomplished by software. The keypad interface is designed with ESD protection.

**Table 4-2. Keypad Map**

| | COL 0 | COL 1 | COL 2 | COL 3 | COL 4 |
|---|---|---|---|---|---|
| **Row 4** | Softkey 1 | Softkey 2 | Softkey 3 | Softkey 4 | |
| **Row 3** | Start | 1 | 2 | 3 | [▲] |
| **Row 2** | Stop | 4 | 5 | 6 | |
| **Row 1** | | 7 | 8 | 9 | [▼] |
| **Row 0** | On/Off | Clear | 0 | . | Silence |

#### 4.2.1.14
## FRONT PANEL [ON/OFF] KEY

The **[ON/OFF]** key on the front panel provides a start up (STRTUP) signal to wake up the power supply when the system is shutdown. When activated during normal operation, the **[ON/OFF]** key interrupts (STRUPD*) the CPU, signaling a request for shutdown.

#### 4.2.1.15
## FRONT PANEL LED INDICATORS

The CPU drives the three light emitting diode (LED) indicators embedded in the front panel. Two memory mapped I/O signals activate the two LED lights used to indicate which channel is in delivery mode (LEDAE*, LEDBE*). The AC power on LED indicates the status of AC power (LEDAC) and that the system is in the battery charge mode. A buffered AC on signal (BACON) drives the LED and is active only when AC power is present.

#### 4.2.1.16
## KEYPAD LOCKOUT INTERFACE

A lockout switch (SW1) on the peripheral interface PWA locks the front panel keypad for all three infusers. A memory mapped input port (LOTSW*) reads the switch. The switch serves as a lockout request and software performs the lockout.

#### 4.2.1.17
## NURSE CALL INTERFACE

A nurse call relay switch on the peripheral interface PWA indicates alarm conditions to a remote operator. A memory-mapped output signal (NURSE) activates the relay during alarm conditions. The relay has both normally-open and normally-closed contacts. A jumper on the peripheral interface board selects the contact type. The factory setting is normally-open.

#### 4.2.1.18
## AUDIBLE INDICATORS

There are two audible indicators on the CPU subsystem. Three loud, main audible indicators are mounted on the main chassis. This main alarm is used to alert the operator to alarm conditions. A keypad beeper, with lower power and a distinctly different tone, is used to provide audible feedback to the operator. The keypad beeper is driven by a memory-mapped output (KEYALM). It is used to indicate keypad activation, and confirmation to the operator.

The main alarm has an adjustable volume control on the peripheral interface PWA, mounted on the rear of the device. The main alarm can be activated by either a memory-mapped control (MAINALM), the reset pulse(s), or by a power failure alarm latch. The main alarm will sound a chirp for every reset pulse sent by the watchdog timer IC. Continuous chirping indicates a stuck processor.

The alarm is activated continuously during power failure. If the control software does not shut down power in a proper sequence, a latch on the CPU PWA, powered by a backup supply (0.1 F supercap), will activate a continuous alarm. This continuous alarm sounds until either the backup supply is discharged or the user resets the latch by pressing the **[ON/OFF]** key. Reliable operation of the main alarm is assured by software monitoring of a buzzer test signal (FBUZTST) via the ADC.

#### 4.2.1.19
## BARCODE READER INTERFACE

> **Note:** The barcode reader feature will not be present on later versions of the Plum A+3.

The CPU communicates with a barcode wand that is connected to the peripheral PWA from the rear of the infuser. The barcode wand reads and decodes a Code 128 barcode symbology and outputs the barcode data via an RS-232 port using an asynchronous, serial ASCII format.The software controls power to the barcode reader and to the interface circuits via memory-mapped outputs BARPWR and COMPWR*. The barcode reader is isolated from the main system by an optical data path on the peripheral PWA and an isolated power supply.

#### 4.2.1.20
## DATAPORT INTERFACE

The CPU communicates with an external computer by way of a DataPort interface. The DataPort interface provides for remote monitoring of up to four infusers using a host computer with a modified RS-232-D serial interface. Infusers are either connected directly to the host or in a daisy chain configuration using junction boxes that provide a 5 bit hard ID via DIP switches on the junction box. The DIP switches are buffered and read by the CPU via the memory-mapped input/output (MMIO) port.

The DataPort system conforms to the EIA-232-D standard, with the following exceptions:

- DataPort uses non-standard DB-15 and 6 pin modular connectors in addition to the standard DB-25 and DB-9 connectors
- With DataPort, more than one infuser is allowed on the line
- The minimum line impedance is 2 KΩ (EIA-232-D standard: 3 KΩ min.)
- The maximum line impedance is 30 KΩ (EIA-232-D standard: 7 KΩ max.)
- The maximum line capacitance is 13 nF (EIA-232-D standard: 2,500 pF)

The communications default is 1200 BAUD, no parity, 8 data bits and 1 stop bit. The BAUD rate is selectable (1200, 2400, 4800, and 9600). The data format on the serial port is a 10 bit frame with asynchronous start and stop. The CTS line is held high and the RTS line is disconnected.

The DataPort is isolated from the main system by an optical data path on the peripheral PWA and an isolated power supply.

#### 4.2.1.21
## POWER SUPPLY INTERFACE

The CPU subsystem interfaces the power supply subsystem by providing the MMIO signals needed for power control and battery management. Additionally, the CPU subsystem measures the battery terminal voltage and charge/discharge current via the ADC.

See *Table 4-3* for CPU-power supply interface signals.

**Table 4-3. CPU-Power Supply Interface**

| Signal Name | Type | Description |
|---|---|---|
| PWRHLD | **D, O** | Holds system power on |
| STRTUP | **A, I** | Startup pulse from the [ON/OFF] key |
| STRUPD* | **D, I** | Digital startup pulse, used as interrupt to the CPU |
| V3_3 | **P** | 3.3 V system power |
| V5_0/VANA | **P** | 5 V analog and interface power |
| VMOT | **P** | Raw, unregulated charger voltage or battery voltage |
| V2_7 | **P** | 2.7 V backup power for RTC and non-volatile SRAM |
| VSC | **P** | Full time 5 V supply, backed up by supercap |
| V12_0 | **P** | 12 V, low current supply for audio alarm |

| Table 4-3. CPU-Power Supply Interface | | |
|---|---|---|
| **Signal Name** | **Type** | **Description** |
| OVRVLT* | **D, I** | Signal that indicates overvoltage, regulation problem on the power supply main regulator |
| BACON | **D, I** | Buffered AC on signal |
| IBATT | **A, I** | Voltage proportional to integration of battery charge/discharge current |
| VBATT | **A, I** | Divided battery terminal voltage |
| CHG* | **D, O** | Battery charger enable |
| VFLOAT* | **D, O** | Set the main regulator voltage to battery float charge level |
| ITGRST | **D, O** | Reset the charge current integrator |

**Legend:** **P** = Power **A** = Analog **D** = Digital **I** = Input **O** = Output

#### 4.2.1.22
## MECHANISM INTERFACE

The CPU subsystem provides the MMIO ports for interface to the mechanism subsystem, in addition to the analog interface mentioned in *Section 4.2.1.11* and *Section 4.2.1.12*.

See *Table 4-4* for CPU-mechanism interface signals.

| Table 4-4. CPU-Mechanism Interface Signals | | |
|---|---|---|
| **Signal Name** | **Type** | **Description** |
| MI_STA | **A, O** | Motor current set for phase A |
| MI_STB | **A, O** | Motor current set for phase B |
| GDAC | **A, O** | Ground signal from chopper (for compensation) |
| M_PHA | **D, O** | Motor phase A |
| M_PHB | **D, O** | Motor phase B |
| M_SEL1, M_SEL0 | **D, O** | Motor select bits |
| FLCAME | **D, O** | I/O and L/S cam flag sensors enable |
| FLPINE | **D, O** | L/S pin motion detectors enable |
| FLPLE | **D, O** | Plunger motor sensor pair enable |
| FLLS_C | **D, I** | Flag, L/S valve cam sensor |
| FLIO_C | **D, I** | Flag, I/O valve cam sensor |
| FLLS_A | **D, I** | Flag, L/S valve A pin detector |
| FLLS_B | **D, I** | Flag, L/S valve B pin detector |

| Table 4-4. CPU-Mechanism Interface Signals | | |
|---|---|---|
| **Signal Name** | **Type** | **Description** |
| FLPLRO | **D, I** | Flag, plunger rotation sensor |
| FLPLTR | **D, I** | Flag, plunger translation sensor |
| PXPRE | **D,O** | Proximal pressure sensor enable |
| PXPRS | **A, I** | Proximal pressure sensor |
| DIPRE | **D, O** | Distal pressure sensor enable |
| DIPRS | **D, O** | Distal pressure sensor |
| PXARE | **D, O** | Proximal air sensor enable |
| PXAIR | **A, I** | Proximal air sensor |
| DIARE | **D, O** | Distal air sensor enable |
| DIAIR | **A, I** | Distal air sensor |
| CASPR* | **D, I** | Cassette present |
| CASS2*, CASS1*, CASSO* | **D, I** | Cassette type coding: Macro (111), Micro (010)<br>All others are invalid |
| SPCLK | **D, O** | SCP clock output |
| SPRXD | **D, I** | SCP receive data |
| SPTXD | **D, O** | SCP transmit data |
| CSSEP* | **D, O** | Chip select, EEPROM |
| V5_0 | **P** | 5 V supply for interface power |
| V3_3 | **P** | 3.3 V supply for logic power |
| GDIG | **P** | Digital ground |
| VANA | **P** | 5 V supply for analog power |
| GANA | **P** | Analog ground |
| VMOT, GMOT | **P** | Motor power is directly from power supply PWA |
| V2_5 | **A, I** | Reference voltage for ADC and DAC |

**Legend:** **P** = Power **A** = Analog **D** = Digital **I** = Input **O** = Output

## 4.2.2
# POWER SUPPLY SUBSYSTEM

The power supply subsystem provides DC power to system circuits and interface software controlled power and battery management.

The power supply subsystem provides for the following functions:

- Main switching regulator
- AC power detection
- Main regulator fault detection
- System power (secondary regulators)
- Auxiliary supplies
- Power control
- Battery charging circuitry
- Battery terminal voltage measurement
- Battery charge/discharge current measurement

### 4.2.2.1
## MAIN SWITCHING REGULATOR

The main source of power for the infuser is the AC line. The main switching regulator is a pulse width modulated, AC-to-DC converter that provides the system an isolated DC voltage of 6.9 $V_{DC}$ (or 7.5 $V_{DC}$ in battery charger boost mode). The main regulator is preceded by line fuses F1 and F2, surge suppressor VR1, and a line filter. The bridge rectifier U14 and capacitors C52 and C53 provide the DC voltage required for the switching circuit. Voltage regulator U13 provides the pulse width modulator (PWM) device U12 startup supply voltage. After startup, supply voltage for U12 is supplied by half wave rectifier circuitry CR14, R76, and C51.

The PWM oscillation frequency is approximately 40 kHz, determined by external resistor R72 and capacitor C45. U12 controls the power delivered by varying the duty cycle of MOSFET Q9 that drives T2. A half-wave rectifier rectifies the transformer's secondary voltage that provides the raw DC voltage for the battery charger and system power.

There following three feedback mechanisms maintain control: a main loop for normal control, a secondary loop for overvoltage protection, and a current limit loop.

#### *4.2.2.1.1*
### *Main Loop*

The main loop uses an optical feedback path to regulate the charger voltage (BATPOS) at 6.9 $V_{DC}$ (except during boost charge, when the limit is raised to 7.5 $V_{DC}$ by software control of the VFLOAT* line). A shunt regulator and opto-isolator provide feedback to the PWM error amplifier.

#### *4.2.2.1.2*
### *Secondary Loop*

Diode CR10 and opto-isolator U10 provide overvoltage protection. CR10 conducts and activates U10 when secondary voltage exceeds approximately 10 $V_{DC}$. The duty cycle of U12 is reduced until the excessive voltage is removed.

#### 4.2.2.1.3
### *Current Limit Loop*

The current limit loop is activated when the primary current, sensed by R71, exceeds 3 A. Resistor R70 and capacitor C46 filter the voltage across R71 and feed it back to the current sense input (1.5 $V_{DC}$ threshold) of U12. The duty cycle of U12 is reduced until the excessive load is removed.

#### 4.2.2.2
## MAIN REGULATOR FAULT DETECTION

If the switching regulator's main loop fails, the secondary voltage limit loop takes over. However, the battery charger and motors must be disabled, and an alarm must be generated. A comparator is used to monitor the raw DC (+BUSS) for overvoltage. A 3.3 $V_{DC}$ logic signal (OVRVLT*) is provided to the CPU subsystem.

#### 4.2.2.3
## SYSTEM POWER

Along with the unregulated VMOT supply, a secondary switching regulator provides system power. The secondary switching regulator includes IC U4, transformer T1, and transistors Q4 and Q5. The regulator is a triple output, wide supply range, fly-back converter that provides regulated 3.3 $V_{DC}$, 5 $V_{DC}$, and 12 $V_{DC}$ outputs from the five winding transformer T1. The regulator operates over an input range of 4 $V_{DC}$ to 10 $V_{DC}$ and provides output current limit as well as voltage overshoot limit. Primary feedback is metered through a bias arrangement on transistor Q3. A Schottky rectifier diode CR4 provides feedback in the event of V3_3 or V12_0 failure, and transistor Q10 provides feedback in the event of V5_0 failure. The positive terminal of the battery provides the raw DC voltage, VMOT, for the motors and backlight of the display.

#### 4.2.2.4
## AUXILIARY SUPPLIES

The power supply subsystem provides full time 5 $V_{DC}$ and 2.7 $V_{DC}$ supplies that are active when battery or AC voltage is present. The full time 5 $V_{DC}$ supply (VSC) uses a linear low dropout voltage regulator U6, whose power source is directly from the battery and is backed up by a 0.1 F capacitor. VSC is used for the ON/OFF switch and a power failure alarm latch. The full time 2.7 $V_{DC}$ supply (V2_7) is derived from VSC and is used to supply the ultra-low current needed to power the real-time clock and non-volatile SRAM during shutdown.

#### 4.2.2.5
## POWER CONTROL

The infuser will operate in one of the following three modes: normal, standby, or shutdown. During normal operation, the user interface is active and either on battery or AC line power. During standby mode the user interface is inactive while the CPU is still operating, servicing the battery management and waiting for a startup interrupt. Shutdown mode is when system power is off. Shutdown mode only occurs during battery operation; otherwise, +BUSS holds the system power on.

The infuser is activated when the **[ON/OFF]** key is pressed or the AC line is plugged in. The **[ON/OFF]** key activates the STRTUP signal, triggering a three second one-shot circuit that will temporarily turn the system power on. This three second one-shot period allows the CPU enough time to power up, initialize, and turn on the PWRHLD signal. The CPU monitors the STRTUP signal, via interrupt, to signal a user request for turning off the infuser.

*Figure 4-3* illustrates the system startup/shutdown sequence while battery powered. System power is always on while AC powered.

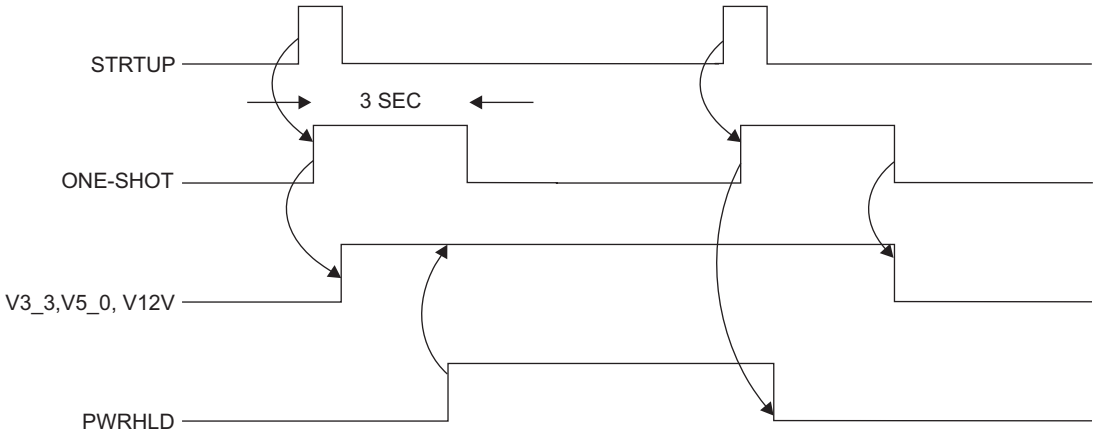


**Figure 4-3. System Startup and Shutdown Timing, Battery Powered**

#### 4.2.2.6
## BATTERY VOLTAGE MEASUREMENT

The battery terminal voltage (BATPOS - BATNEG) is measured with a differential amplifier consisting of U1, R1, R2, R4, R7, and R8. It has a gain of 0.317 to generate a single ended VBATT signal. The VBATT signal is then provided to the CPU A/D converter as input for the battery management algorithms.

#### 4.2.2.7
## BATTERY CHARGE/DISCHARGE CURRENT MEASUREMENT

The battery management algorithms measure battery charge/discharge current for battery capacity estimation and charger control. The charge/discharge current is measured by integrating the voltage across current sense resistor R57. An operational amplifier (op-amp) integrator circuit, consisting of U2, C5, R12, R13, R19, and R20, provides a voltage proportional to the integration of battery current (IBATT) over a CPU controlled measurement period. The IBATT signal is fed to the CPU A/D converter, where it is sampled at the end of the measurement period. The battery management algorithm further accumulates the charge/discharge current for battery capacity estimation.

The op-amp integrator is reset by the CPU system at the beginning of each measurement period by parallel analog switches U3, controlled by the CPU's ITGRST signal. The battery management algorithm periodically calibrates the op-amp integrator.

#### 4.2.2.8
## BATTERY CHARGER

The software battery management algorithm controls the battery charger. The charging scheme is a current limit/two stage voltage limit charger. The charge current is limited to 1.3 A and the voltage is limited to either 6.9 $V_{DC}$ or 7.5 $V_{DC}$.

The source of the charge current is power MOSFET transistor Q7 operating in the linear mode. Charge current passes through a current sense resistor R57, where it develops a feedback signal for the charger control amplifier consisting of U7, Q6, and associated parts. The feedback signal is compared against a 2.5 $V_{DC}$ voltage reference U8. A 0.5 A fuse protects against damage due to a short circuit. The battery management algorithm maintains on/off control of the charger by the charger enable signal CHG*. When set high, CHG* activates a comparator U7 that overrides the feedback signal and disables the charger. Excessive voltage on the BATNEG terminal indicates there is a shorted battery cell, and will disable the charger through the same comparator.

### 4.2.3
# MECHANISM SUBSYSTEM

The mechanism subsystem includes the electronics and electromechanical components that interface with the pumping mechanism.

The mechanism subsystem provides the following functions:

- Chopper motor drive for three stepper motors (plunger, L/S valve, I/O valve)
- Four motor position sensors (flag detectors)
- Precision voltage reference
- Two air sensors (distal, proximal)
- Two pressure sensors (distal, proximal)
- Cassette presence and type detection
- Serial electrically erasable PROM (EEPROM)

See *Table 4-4* for mechanism interface signals.

#### 4.2.3.1
## MOTORS/MOTOR DRIVE

The infuser uses three stepper motors for pumping; one for fluid displacement and two for cassette valve actuation. The stepper motors are driven, under step-by-step control from software, by a unipolar chopper drive.

*4.2.3.1.1*

## *Stepper Motors*

Each motor is named by its function, as follows:

- Plunger motor for driving the plunger screw
- I/O valve motor for moving the input-output valve pins
- L/S valve motor for moving the line select valve pins A and B

All three motors are four phase stepper types. One electrical revolution is accomplished after four motor steps (phases) are completed. The step-angle (the number of steps per shaft revolution) resolutions are 3.6° /step (100 steps/rev) for the plunger motor, and 7.5° /step (48 steps/rev) for the I/O and L/S valve motors.

The unipolar motor windings have a center tap connected on each of the two coils as shown in *Figure 4-4*. Unidirectional current enters the center tap and is steered to one end of the coil or the other end by the driver electronics, creating positive or negative flux lines in the motor coil. With two coils each with a choice of flux polarity, four electrical combinations or phases are possible.

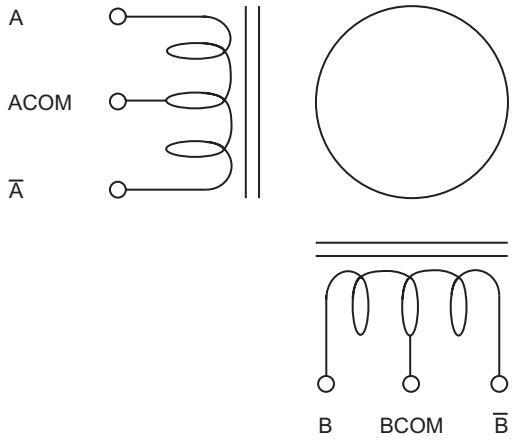


**Figure 4-4. Stepper Motor Coils**

*4.2.3.1.2*

## *Chopper Motor Drive*

The infuser stepper motor drive is a chopper drive that is a pulse width modulation of the coil current in each motor winding. Current is switched on and off to maintain a predetermined coil current independent of supply voltage and motor speed. The motor winding inductance acts as a filter to smooth out the switching currents, slowing the current rise when turned on and storing a decaying current when turned off. Each motor coil is modulated independently, allowing different coil currents in the two motor windings. The coil current is sensed and compared to a reference input for each winding. Modulation circuits correct for any error between the sensed current and the reference. This reference input can be changed to set a different coil current.

#### 4.2.3.2
## MOTOR POSITION SENSORS

Motor position is estimated by counting the motor steps, relative to a position reference. Optical switches and flags serve as position references that are used to find the motor home positions and to verify proper motion. Flag positions are anticipated by software.

Optical switch flag sensors are used for tracking the following:

- Plunger motor rotational position (coupler flag)
- Plunger translational (linear) position
- I/O valve motor rotational position (cam flag)
- L/S valve motor rotational position (cam flag)

Each optical switch consists of an infrared LED that shines through a rectangular aperture, across a slot, to illuminate a photo-transistor. The photo-transistor is activated as long as the beam is on and not blocked (by a flag in the slot). The optical switches are distributed throughout the mechanism, near their associated flags. The motor rotational optical switches are mounted on the driver PWA along with the control circuitry. The plunger translational optical switch is mounted remotely on the switch PWA. The switches are used intermittently to save power.

There are two control signals that enable associated switch pairs, as follows:

- FLCAME flag valve motor cam sensor enable
- FLPLE flag plunger motor rotation and translation sensors enable

Each of these control signals enables a constant current source that turns on the associated switch's infrared LEDs. The photo transistor states are sensed by Schmidt trigger inverters (U11 on driver PWA) that provide a 3.3 V logic high when the optical path is blocked or a logic low when the optical path is clear. The Schmidt trigger output is high when the sensor is disabled.

The following output signals are provided to the CPU subsystem:

- FLIO_C flag I/O valve motor cam sensor
- FLLS_C flag L/S valve motor cam sensor
- FLPLRO flag plunger motor rotation sensor
- FLPLTR flag plunger motor transition sensor

#### 4.2.3.3
## V2_5 REFERENCE VOLTAGE

A precision 2.5 $V_{DC}$ reference voltage is generated on the APP PWA for use by the pressure sensor excitation circuits, the air sensor amplifier circuits, and the ADC and DAC reference voltage. The precision 2.5 $V_{DC}$ reference is buffered by a voltage follower. The signal name is V2_5.

#### 4.2.3.4
## AIR SENSORS

The mechanism subsystem includes two air sensors, used to detect air passage into (proximal) or out of (distal) the cassette. Both sensors are piezoelectric crystal transmitter receiver pairs. Liquid between the transmitter and receiver will conduct the ultrasonic signal, while air will not *(see Figure 4-5)*.

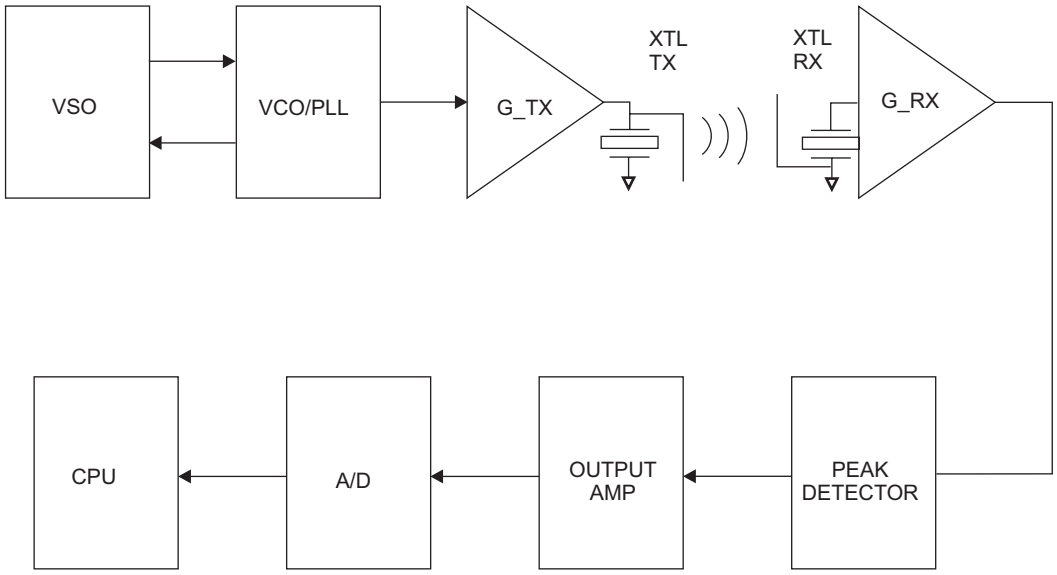


**Figure 4-5. Air Sensor Block Diagram**

#### *4.2.3.4.1*
### *Transmitter Circuitry*

The transmitter circuitry consists of a voltage sweep oscillator, a voltage-controlled oscillator (VCO), and a transmitter amplifier, and are located on the APP PWA.

The voltage sweep oscillator circuit oscillates at approximately 12 kHz at 50 percent duty cycle. The output of the sweep oscillator is between +2 $V_{DC}$ and +3 $V_{DC}$, and is used to sweep the VCO. The VCO sweeps through the sensor's peak coupling frequency that is between 3 MHz and 6 MHz. A resistor and capacitor are used to configure the VCO center frequency. The VCO is enabled when the CPU asserts either DIARE or PXARE control signals.

The transmitter amplifier consists of a push-pull, emitter-follower, complementary pair of transistors. The transmitter amplifier drives both proximal and distal sensors simultaneously.

#### *4.2.3.4.2*
## *Receiver Circuitry*

When the cassette's test port is filled with fluid, the transmitted signal will be coupled to an identical piezoelectric crystal, where it is amplified and detected by the receiver circuitry. The receiver circuitry consists of an amplifier, a peak detector, and an adjustable gain buffer stage. There is a separate, symmetrical receiver circuit for each channel (proximal and distal). Component references (called out in this design description) will be made to the distal channel only.

The first amplifier includes two, directly coupled common emitter stages, biased from the V2_5 supply. DIARE and PXARE are used to enable the distal and proximal sensors, respectively. The detector stage consists of an emitter follower, charging a 400 microsecond time constant, refreshed every 40 microseconds (twice per VCO sweep).

The peak detector output is buffered by an op-amp configured as a basic non-inverting amplifier with a trimming potentiometer (R31) for gain adjustment. Each sensor has an independent gain adjustment. The two air sensor, gain-trimming potentiometers are accessible for calibration in an assembled mechanism.

The following final signals are read by the CPU subsystem via the ADC:

- PXAIR proximal air sensor output
- DIAIR distal air sensor output

#### 4.2.3.5
## PRESSURE SENSORS

The mechanism subsection contains two strain gauge-type pressure sensors, one at the proximal and the other at the distal cassette ports. Electrically, the strain gauge is a Wheatstone bridge made of four strain gauge resistors. When the bridge is electrically excited, the bridge will output a millivolt level signal proportional to the applied pressure. The output signal is amplified and offset adjusted before being read by the ADC. Each pressure sensor circuit includes an excitation voltage supply, sensor amplifiers, and a low pass filter. The pressure sensor circuitry is on the APP PWA. Each of the two channels has an identical topology, but different gain and filter response.

A block diagram of this circuit is shown in *Figure 4-6*. Component references are made to the distal channel only.

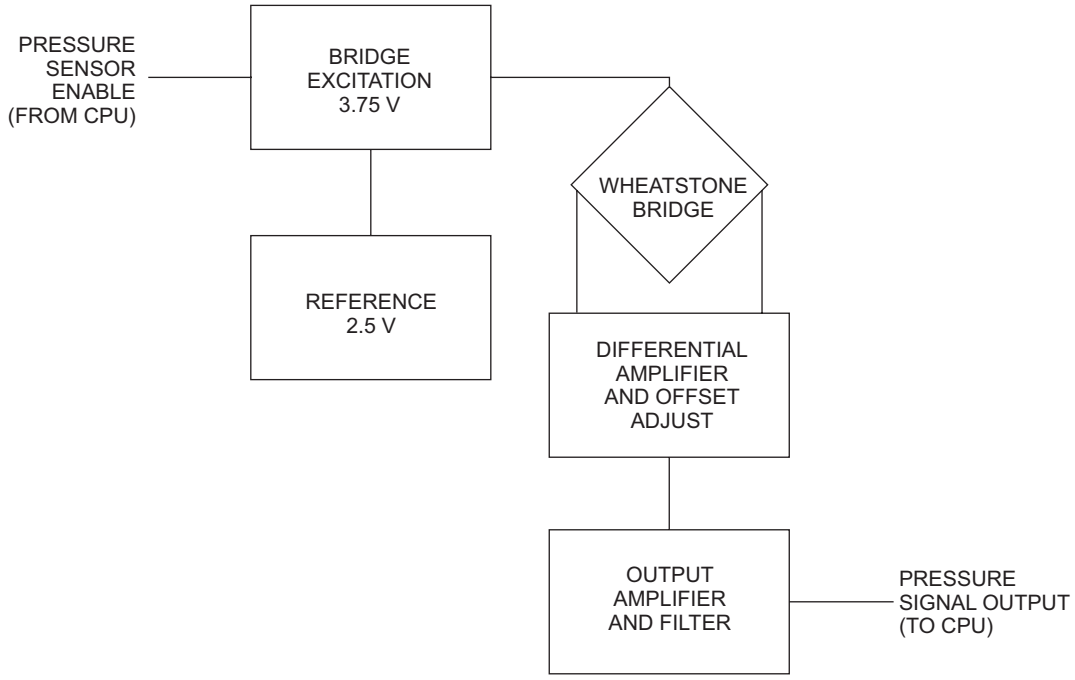


**Figure 4-6. Pressure Sensor Excitation and Amplifier Block Diagram**

*4.2.3.5.1*

## *Bridge Excitation Supply*

The bridge excitation voltage is 3.75 $V_{DC}$, and is derived from the 2.5 $V_{DC}$ reference signal (V2_5), gained 1.5 times by an amplifier. The CPU subsystem may independently enable power to each pressure sensor bridge.

The following enable signals are active high 3.3 V logic level inputs:

- PXPRE proximal pressure sensor enable
- DIPRE distal pressure sensor enable

*4.2.3.5.2*

## *Amplifier and Low Pass Filter*

The pressure sensor amplifiers include a high gain differential pre-amplifier, followed by a second stage non-inverting amplifier with low gain. A trimming potentiometer is adjusted to minimize any offset in the impedance of the bridge.

A two-pole filter is used to filter the pressure signals. The first pole is formed by a capacitor (C39, multiplied by 230 due to Miller effect) and a Thevenin resistance (seen at U4-2). The second pole is the RC filter at the ADC input that is located on the CPU PWA.

Output signals to the A/D converter in the CPU PWA are as follows:

- PXPRS proximal pressure signal
- DIPRS distal pressure signal

#### 4.2.3.6
## PRESSURE SENSOR CALIBRATION

Pressure sensors are calibrated for offset and gain during mechanism calibration. A trimming potentiometer is used to adjust the initial, zero pressure offset. The proximal and distal pressure sensors have independent offset adjustments. The final system gain (cassette pressure to corrected amplifier output) is adjusted in software. During mechanism calibration, each channel's gain (amplifier output/cassette pressure) will be measured, and stored in the serial EEPROM on the driver PWA.

#### 4.2.3.7
## CASSETTE TYPE/PRESENCE SELECTION

The mechanism subsystem includes four force sensing resistor (FSR) switches that are coupled to the cassette. Three FSRs are used for cassette type decoding and one is used for cassette present detection.

The FSR is a polymer thick film device that exhibits a decrease in resistance with any increase in force applied to the active surface. The FSRs have a resistance that is either very large (> 1 MΩ) or relatively small (< 100 KΩ). The large resistance is defined as a logical '0', and the small resistance is defined as logical '1'. Each FSR is arranged in a voltage divider configuration with a fixed resistor, followed by a comparator with hysteresis. The comparator circuits are located on the CPU PWA. The comparators are designed to trip as the FSR's resistance falls below 120 KΩ.

#### 4.2.3.8
## SERIAL EEPROM

The driver PWA holds the 8 K x 8 bit, serial EEPROM that is used to store event, alarm, malfunction, and calibration data specific to the pumping mechanism. It is accessed through a serial peripheral interface (SPI) compatible interface that is a high-speed serial interface to the CPU. The CPU PWA accesses this device through its SCP serial interface. This interface is a subset of the SPI, and consists of clock (SPCLK), data in (SPRXD), and data out (SPTXD) pins. This device is in the driver PWA to allow the calibration data to stay with the mechanism.

# 4.3 PRINTED WIRING ASSEMBLIES

Infusion system electronics are packaged into six printed wiring assemblies (PWA) and several remote mounted peripherals *(see Section 4.4)*. The following sections provide a brief description of the functional interfaces of each PWA.

## 4.3.1 POWER SUPPLY PWA

The power supply PWA contains the following functions of the power supply subsystem:

- Main switching regulator
- AC power detection
- Main regulator fault detection
- System power
- Auxiliary supplies
- Power control
- Battery management

The power supply PWA is a four layer board with primarily surface mount technology (SMT) components. The board is fully testable from the bottom side. An insulating tape covers the back of the power supply PWA. Open system troubleshooting should be done under battery power. If connection to the AC line is required, an isolation transformer should be used since AC line potentials are present on the power supply PWA.

See *Table 4-5* for power supply PWA interface connections.

**Table 4-5. Power Supply PWA Interface Connections**

| Connector | Type | Interface |
|---|---|---|
| **P2** | 30 pin receptacle | Board-to-board connection to CPU PWA |
| **J16** | 4 pin header | Motor power connection to driver PWA |
| **J21** | 3 pin receptacle | AC power cord connection |
| **J22** | 2 pin header | Battery cable connection |

## 4.3.2
# PERIPHERAL PWA

The peripheral PWA contains part of the CPU subsystem circuitry, including system program and data memories (PROM and SRAM), and external communication interface circuits. The peripheral PWA is designed to be field replaceable, to facilitate software upgrades or additional external interfaces.

The peripheral PWA is a four layer board that includes the following: one ground plane, one power plane, and two signal layers. In its initial configuration, all of the components are mounted on the top side.

See *Table 4-6* for peripheral PWA interface connections.

**Table 4-6. Peripheral PWA Interface Connections**

| Connector | Type | Interface |
|---|---|---|
| **P1** | 96 pin receptacle | Board-to-board connection to CPU PWA |
| **J26** | 15 pin D-sub | DataPort |
| **J27** | 9 pin D-sub | Barcode reader connection |
| **J28** | 3 pin phone jack | Nurse call jack |

## 4.3.3
# PERIPHERAL INTERFACE PWA

The peripheral interface PWA contains the following: part of the CPU subsystem circuitry including system program and data memories (PROM and SRAM), external communication interface circuits, and rear instrument user controls.

See *Table 4-7* for peripheral interface PWA interface connections.

**Table 4-7. Peripheral Interface PWA Interface Connections**

| Connector | Type | Interface |
|---|---|---|
| **P1** | 96 pin receptacle | Board-to-board connection to CPU PWA |
| **J29**<br>**J30** | 50 pin plug | Board-to-board connection to peripheral PWA |
| **J26** | 15 pin D-sub | DataPort |
| **J27** | 9 pin D-sub | Barcode reader connection |
| **J28** | 3 pin phone jack | Nurse call jack |

## 4.3.4
# CPU PWA

The CPU PWA contains most of the CPU subsystem functions, with the exception of main memory and communications ports that are located on the peripheral PWA. The CPU PWA also accommodates system interconnect.

The CPU PWA is an eight layer board with the following: one ground plane, one power plane, and six signal layers. The CPU PWA primarily contains SMT components. Most of the components are on the top side, while the bottom side holds wave-solder compatible SMT resistors and capacitors.

See *Table 4-8* for CPU PWA interface connections.

**Table 4-8. CPU PWA Interface Connections**

| Connector | Type | Interface |
|---|---|---|
| **J7** | 96 pin header | Connection to peripheral PWA<br>(CPU bus, rear panel I/O, and communication ports) |
| **J2** | 30 pin header | Connection to power supply PWA |
| **J3** | 50 pin SMT | Ribbon cable connection to driver PWA (mechanism) |
| **J4** | 21 pin header | Front panel connector (keypad, LEDs, On/Off switch) |
| **J5** | 14 pin SMT | Flat flex cable to LCD panel |
| **J20** | 4 pin header | CCFT backlight connector |
| **J24** | 2 pin header | Main audible alarm connector |

## 4.3.5
# DRIVER PWA

The driver PWA contains the mechanism subsystem's motor drive circuitry, motor position sensors, and serial EEPROM. The driver PWA is mounted in the mechanism sub-chassis.

The driver PWA is a four-layer PWB with the following: one ground plane, one power plane, and two signal layers. The driver PWA primarily uses SMT components. Most of the components are located on the top side of the board, while the bottom side holds wave-solder compatible resistors and capacitors.

See *Table 4-9* for driver PWA interface connections.

**Table 4-9. Driver PWA Interface Connections**

| Connector | Type | Interface |
|---|---|---|
| **J7** | 6 pin header | Plunger motor |
| **J8** | 6 pin header | Input/output motor |
| **J9** | 6 pin header | Line select motor |
| **J10** | 20 pin SMT | Flat flex cable to APP PWA |
| **J11** | 50 pin header | Ribbon cable to CPU PWA |
| **J12** | 6 pin SMT | FSR flex circuit |
| **J13** | 4 pin header | Motor power, from power supply PWA |
| **J14** | 8 pin SMT | Flat flex cable to switch PWA |

### 4.3.6
## SWITCH PWA

The switch PWA contains the plunger translation position sensor that is one of four position sensors in the system. The switch PWA is located at the side of the mechanism sub-chassis, and connects to the driver PWA.

### 4.3.7
## APP PWA

The APP (air, pressure, and pin) PWA is mounted in the mechanism sub-chassis, and contains the following mechanism subsystem circuitry:

- Proximal and distal air sensors and circuitry
- Proximal and distal pressure sensor amplifiers and excitation
- V2_5 precision voltage reference
- Pin detector optical switch module

The APP PWA is a four layer board with the following: one ground plane, one power plane, and two signal layers. The APP PWA uses SMT components, mounted on both sides of the board. The air sensors and the pin detector module are board mounted.

See *Table 4-10* for APP PWA interface connections.

**Table 4-10. APP PWA Interface Connections**

| Connector | Type | Interface |
|---|---|---|
| **J15** | 20 pin SMT | Flat flex cable to driver PWA |
| **J11** | 10 pin SMT | Pressure sensor connector |

# 4.4 REMOTE MOUNTED PERIPHERALS

Remote mounted peripherals include the LCD, sealed lead acid battery, and barcode reader (BCR) wand.

## 4.4.1 LCD

The infuser uses a graphic LCD module with a CCFT. The CCFT provides a backlight source for the LCD. The LCD requires a nominal -16 $V_{DC}$ supply for contrast control that is controlled by the CPU. The infuser's graphic display data is shifted out to the LCD by the CPU LCD controller that interfaces directly with the CPU *(see Section 4.2.1.6)*. The display is configured as a 240 x 240 dot matrix with a viewing angle of approximately 60°.

## 4.4.2 SEALED LEAD ACID BATTERY

The infuser uses a nominal 6 $V_{DC}$ rechargeable sealed lead acid battery with a 4 amp-hour capacity.

## 4.4.3 BARCODE READER WAND

> **Note:** The barcode reader feature will not be present on later versions of the Plum A+3.

The barcode reader wand connects to the BCR port J27 on the peripheral PWA. The BCR wand interfaces through the infuser's optically isolated, TTL logic level, asynchronous interface. The BCR wand is also capable of interfacing at RS-232 levels. The infuser provides an isolated +5 $V_{DC}$ regulator to power the BCR wand. When the LED at the tip of the BCR wand is swiped across a barcode label, the reflected light is scanned and processed. After a successful scan, the data is sent over the communication interface to the CPU.

# 4.5 MECHANICAL OVERVIEW

The principal mechanical elements of the infuser include the cassette and the mechanism assembly. When a cassette is locked into the operating position and the **[ON/OFF]** switch is pressed, the infuser performs a self test to verify the integrity of the internal systems. The operation of the mechanism assembly moves a plunger, causing a pumping action. A valve motor selects the A or B valve, depending on the command. An additional valve motor alternately opens and closes an inlet valve and outlet valve to control fluid flow through the cassette pumping chamber.

The following sections detail the cassette and the mechanism assembly.

## 4.5.1
# CASSETTE

The cassette *(see Figure 4-7* and *Figure 4-8)* operates on a fluid displacement principle to volumetrically deliver fluid. See the system operating manual for a description of the major cassette functions.

The pumping cycle begins when the outlet valve is opened and the inlet valve is closed. The plunger extends to deflect the cassette diaphragm and expel fluid. At the end of the pumping stroke, the outlet valve is closed, the inlet opens, the appropriate A or B valve opens, and the plunger retracts to allow fluid to refill the pumping chamber. After the pumping chamber is filled, the inlet and outlet valves are reversed, the A and B valves are closed, and the cycle repeats.

The cassette contains an upper air trap chamber and a pumping chamber. The two chambers are separated by an inlet valve and operate together to detect air. The air trap chamber receives fluid from the intravenous (IV) container through either the A or B valve. The air trap chamber collects air bubbles from the IV line and container to prevent them from entering the pumping chamber and can collect a substantial amount of air.

A proximal air-in-line sensor (bubble detector) is located between the A/B valves and the upper air-trap chamber. The proximal air-in-line sensor detects air entering the upper air-trap chamber and initiates an audible alarm if the predetermined air collection threshold is exceeded. Similarly, a second air-in-line sensor located distal to the pumping chamber initiates an audible alarm if a predetermined amount of air is detected.

The pumping chamber receives fluid from the upper air-trap chamber through an inlet valve. A pressure sensor located in the upper air-trap chamber monitors pressure on the proximal side of the cassette. When the diaphragm covering the pumping chamber is deflected by the plunger, the pumping chamber expels fluid through an outlet valve. A pressure sensor located distal to the pumping chamber monitors pressure on the distal side of the cassette.

A flow regulator is incorporated into the cassette distal end. This flow regulator is used to manually control flow when the cassette is not inserted in the infuser. When the cassette is properly inserted into the infuser and the door is closed, a mechanism opens the flow regulator to allow the infuser to control fluid flow. When the door is opened, the same mechanism closes the flow regulator to disable fluid flow.

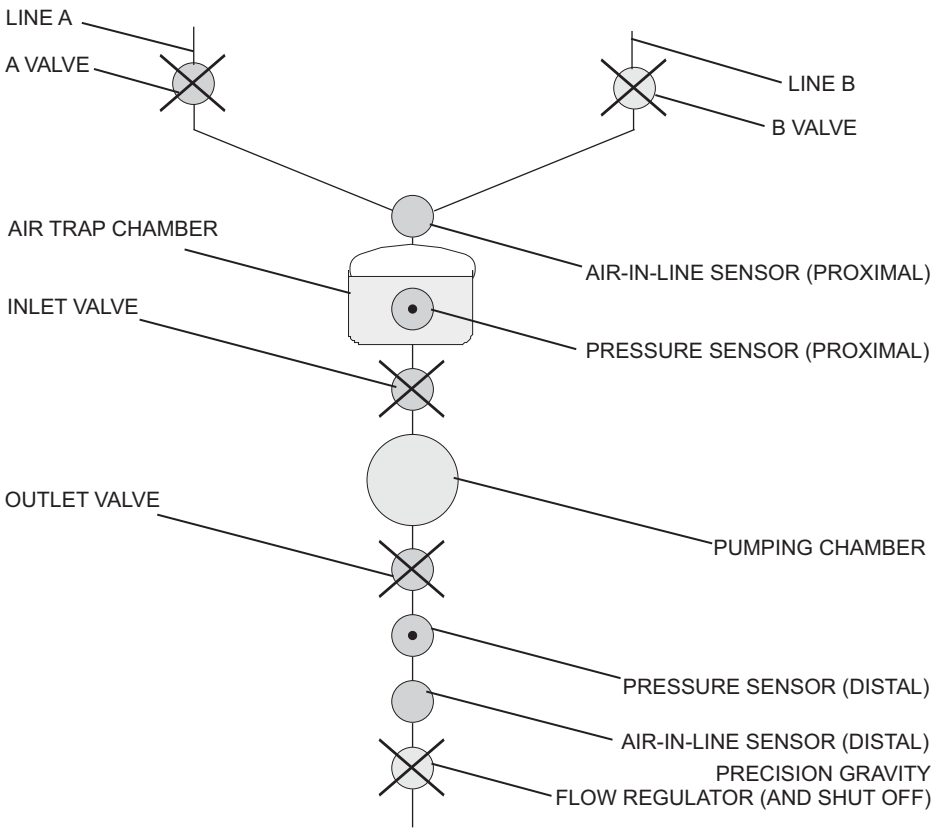


**Figure 4-7. Major Elements of the Dual-Channel Cassette**

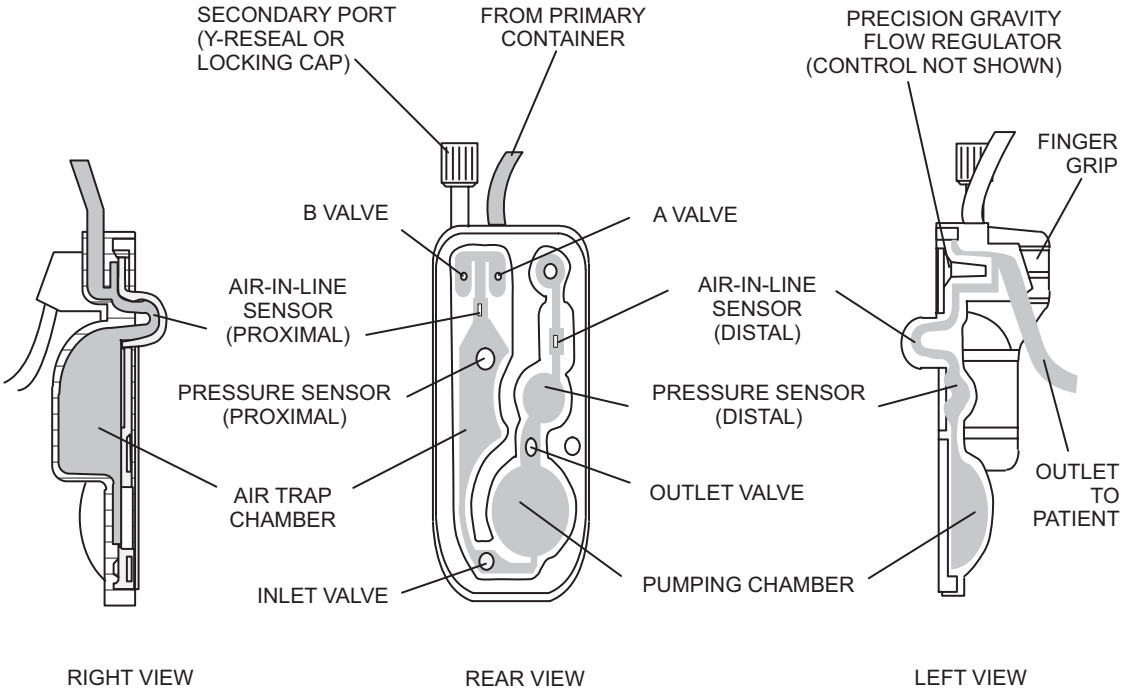


**Figure 4-8. Fluid Path in the Cassette**

## 4.5.2
# MECHANISM ASSEMBLY

The mechanism assembly is a fully self-contained unit consisting of the motor and valve assemblies, A/B valve subsystem, inlet/outlet valve subsystem, plunger drive subsystem, air bubble (ultrasonic) sensor assemblies, cassette door, and pressure sensor assemblies. The motor and valve assemblies, A/B valve subsystem, inlet/outlet valve subsystem, and plunger drive subsystem are detailed in the following sections.

During infuser operation, the mechanism assembly plunger motor drives a lead screw that is coupled to the plunger. The motor action and lead screw move the plunger forward to cause the delivery of approximately 0.33 mL of fluid per cycle. The plunger motion is synchronized to the valve motors to provide controlled fluid delivery.

See *Figure 4-9* for mechanism valve pins and sensor locations.

## 4.5.2.1
## MOTOR AND VALVE ASSEMBLIES

The mechanism assembly pumping action is controlled by three stepper motors. The first stepper motor, in conjunction with an associated valve assembly, activates the A or the B valve of the cassette, depending on the command. The second stepper motor alternately opens and closes the inlet and outlet valve to control fluid delivery through the cassette pumping chamber. A third stepper motor controls plunger movement.

## 4.5.2.2
## A/B VALVE SUBSYSTEM

The A/B valve subsystem includes a motor designed to rotate a cam. When the cam is positioned at top-dead-center (home position), both valves are closed. Clockwise rotation (when viewed from the motor side) from the home position opens the A valve, while the B valve remains closed. Counterclockwise rotation opens the B valve, while the A valve remains closed.

The A/B valve subsystem consists of a stepper motor with attached cam and integral cam flag, A and B rockers and valve pins, and a pin detector assembly. The cam flag passes through an interrupter module as it rotates with the cam. Valve home position is determined by this cam flag/interrupter module combination through predetermined factory calibration data. During operation, if the cam flag passes through the interrupter module at the incorrect time sequence, a motor phase loss is detected. The rocker is the connecting link between the cam and the valve pin.

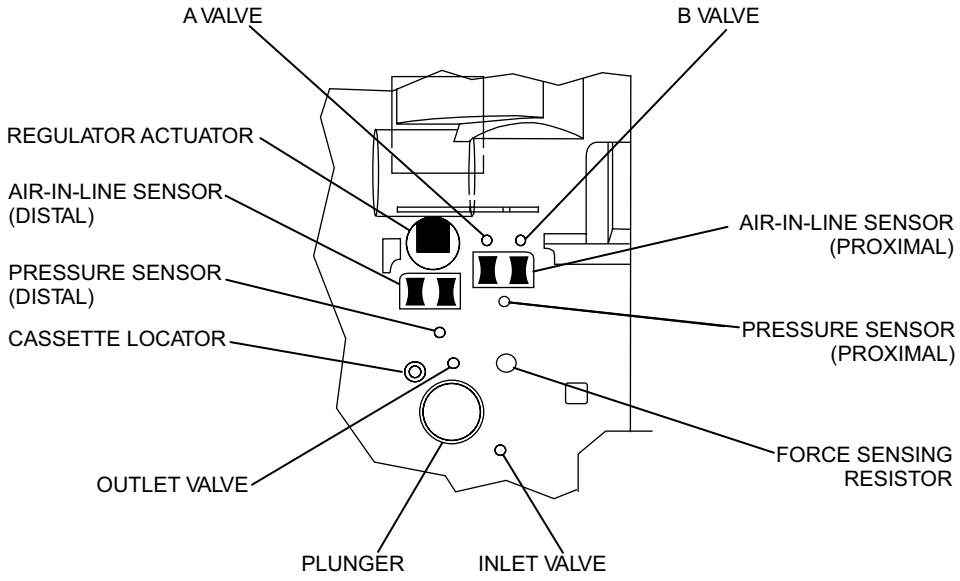


**Figure 4-9. Mechanism Valve Pins and Sensor Locations**

#### 4.5.2.3
## INLET/OUTLET VALVE SUBSYSTEM

The inlet/outlet valve subsystem is similar in function and build to the A/B valve subsystem *(see Section 4.5.2.2)*.

#### 4.5.2.4
## PLUNGER DRIVE SUBSYSTEM

The main components of the plunger drive subsystem are plunger, lead screw and coupler, and stepper motor. When the infuser is turned on, the plunger moves from the retracted, PARK position to the HOME position. The cassette diaphragm is engaged. The stepper motor rotates approximately 1 2/3 revolutions per pump cycle to permit a 0.33 mL fluid displacement every pump cycle. The stepper motor then reverses and the plunger returns to HOME position. This cycle repeats for the duration of fluid administration.

The screw/coupler assembly links the motor and the plunger. This assembly includes a flag that passes through an interrupter module. This screw/coupler, flag/interrupter module combination is used in conjunction with predetermined factory calibration data to determine the plunger position. During operation, if the screw/coupler flag passes through the interrupter module at the incorrect time sequence, a motor phase loss is detected.

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Section 5

# MAINTENANCE AND SERVICE TESTS

A complete maintenance program promotes infusion system longevity and trouble-free operation. Such a program should include routine maintenance, periodic maintenance inspection, and following any repair procedure, performance verification testing.

## 5.1 ROUTINE MAINTENANCE

Routine maintenance consists of basic inspection and cleaning procedures. As a minimum requirement, inspect and clean the infuser after each use. In addition, establish a regular cleaning schedule for the device.

### 5.1.1 CLEANING AND SANITIZING

Practice the cleaning and sanitizing guidelines in this section. Follow hospital protocol for establishing the infuser cleaning schedule.

Before cleaning, turn off the infuser and disconnect from AC power.

Clean the exposed surfaces of the infusion system with a soft, lint-free cloth moistened with one of the cleaning solutions listed in *Table 5-1*, or a mild solution of soapy water. Remove soap residue with clear water. Use a small, non-abrasive brush to aid in cleaning the cassette door.

**WARNING: DISCONNECT THE INFUSER FROM AC POWER PRIOR TO CLEANING THE DEVICE. FAILURE TO COMPLY WITH THIS WARNING COULD RESULT IN ELECTRICAL SHOCK.**

**CAUTION: To avoid mechanical or electronic damage, do not immerse the infuser in fluids or cleaning solutions. Do not spray cleaning solutions toward any openings in the device or directly on the device.**

**CAUTION: Use only recommended cleaning solutions and follow manufacturers' recommendations. Using cleaning solutions not recommended by Hospira may result in product damage. Do not use compounds containing combinations of isopropyl alcohol and dimethyl benzyl ammonium chloride.**

**CAUTION: Never use sharp objects such as fingernails, paper clips, or needles, to clean any part of the infuser. Use only soft cloths or sponges. Do not sterilize by heat, steam, ethylene oxide (ETO), or radiation.**

**Note:** Disinfecting properties of cleaning solutions vary, and not all cleaning solutions are sanitizers. Check product labeling or consult the manufacturer for specific information.

**Table 5-1. Cleaning Solutions**

| Cleaning Solution | Manufacturer | Preparation |
|---|---|---|
| Coverage® HB | Steris | Per manufacturer's recommendation |
| Dispatch® Hospital Cleaner Disinfectant with Bleach | Caltech Industries | Per manufacturer's recommendation |
| Manu-Klenz® | Steris | Per manufacturer's recommendation |
| Precise® Hospital Foam Cleaner Disinfectant | Caltech Industries | Per manufacturer's recommendation |
| Sani-Cloth® HB Wipe | Professional Disposables | Per manufacturer's recommendation |
| Sani-Cloth® Bleach Wipe | Professional Disposables | Per manufacturer's recommendation |
| Sporicidin® | Sporicidin | Per manufacturer's recommendation |
| Household Bleach (Sodium Hypochlorite) | Any | Use per hospital procedures<br>Do not exceed one part bleach in ten parts water |

**Note:** At the time of printing, Hospira recommends only the cleaning solutions in *Table 5-1*. For updated listings of approved cleaners, visit **www.hospiraparts.com**.

## 5.2
# PERFORMANCE VERIFICATION TEST

The Performance Verification Test (PVT) consists of the tests described in the following sections. The PVT is designed to assure the infusion system is operating properly, and can also be used for diagnostic purposes during troubleshooting. The PVT should be used for performance verification before an infuser is placed back in service after repair.

**Note:** Perform the PVT exactly as described in this manual to assure effective and reliable product evaluation information.

If any malfunction is detected as a result of the PVT, see *Section 6*.

## 5.2.1
# EQUIPMENT REQUIRED

The PVT requires the following equipment, or equivalents:

- Graduated cylinder, 25 mL, with 0.2 mL graduations (Type A)
- Sterile water or tap water in an IV bag/container
- Digital pressure meter (DPM), 0 to 50 psi (Fluke® Biomedical DPM3)
- Three-way stopcock, latex-free (List No. 3233-01)
- IV Set (List No. 1642)
- Secondary Piggyback Set (List No. 1832)
- 21-gauge butterfly needle, latex-free (List No. 4492-01), or 18-gauge blunt cannula
- Safety analyzer (Fluke® Biomedical 232D)
- Digital multimeter (DMM), (Fluke® 187)
- Nurse call test cable (P/N 561-88416-001)

## 5.2.2
# INSPECTION

Inspect the infusion system periodically for signs of defects such as worn accessories, broken connections, or damaged cables. In addition, inspect the infusion system after repair or during cleaning. Replace any damaged or defective external parts.

Inspect the following areas for missing or damaged parts:

- Labels
- AC power cord, retainer, and straps
- Rubber foot pads
- Door assembly and handle
- Keypad and display
- LEDs
- External screws
- Pole clamp assembly
- Front and rear enclosures
- Battery doors
- Peripheral interface assembly and components

## 5.2.3
# TEST SETUP

**WARNING: A PATIENT SHOULD NEVER BE CONNECTED TO THE INFUSER DURING DEVICE TESTING.**

To set up the infuser for the PVT, proceed as follows:

1. Confirm the infuser and appropriate accessories are assembled.
2. Hang two sterile water containers at a height of 18 ± 6 inches above the pumping chamber of the infuser.
3. Connect the infuser to AC power, and press **[ON/OFF]** to turn on the device.
4. Verify the infuser is in the **unlocked** mode. Toggling the **[LOCKOUT]** switch alternates between **unlocked [DOWN]** and **locked [UP]** modes.
5. Turn off the infuser.

## 5.2.4
# SELF TEST

**CAUTION: Do not place the infuser in service if the self test fails.**

Conduct all tests with the infuser connected to AC power unless otherwise specified.

If an alarm condition occurs during the self test, cycle the power and repeat the self test. If the alarm condition recurs, note the message and take corrective action *(see Section 6)*. Repeat the self test. If the alarm condition continues to recur, remove the infuser from service and contact Hospira.

To perform the self test, see *Figure 5-1*, then proceed as follows:

1. Connect the AC power cord to a grounded AC outlet. Verify the charge/line indicator **CHARGE** illuminates and an alarm tone sounds.
2. Without a cassette installed, turn on the infuser.
3. The LCD screen briefly displays the **SELF TEST** screen *(see Figure 5-1)*. If the **SELF TEST** screen does not appear, contact Hospira.
4. After the self test is complete, the message **INSERT PLUM SET CLOSE LEVER** appears.
5. Verify the time and date. To set the time and date see *Section 1.8.3*.
6. Open the cassette door and insert a primed cassette. Close the cassette door. The cassette test is complete when the **CASSETTE TEST IN PROGRESS** message disappears.

   **Note:** The message **MECHANISM INITIALIZATION IN PROGRESS** may briefly appear prior to the **CASSETTE TEST IN PROGRESS** message.

7. The **CLEAR SETTINGS?** message may appear. Press **[YES]**, then turn off the device.

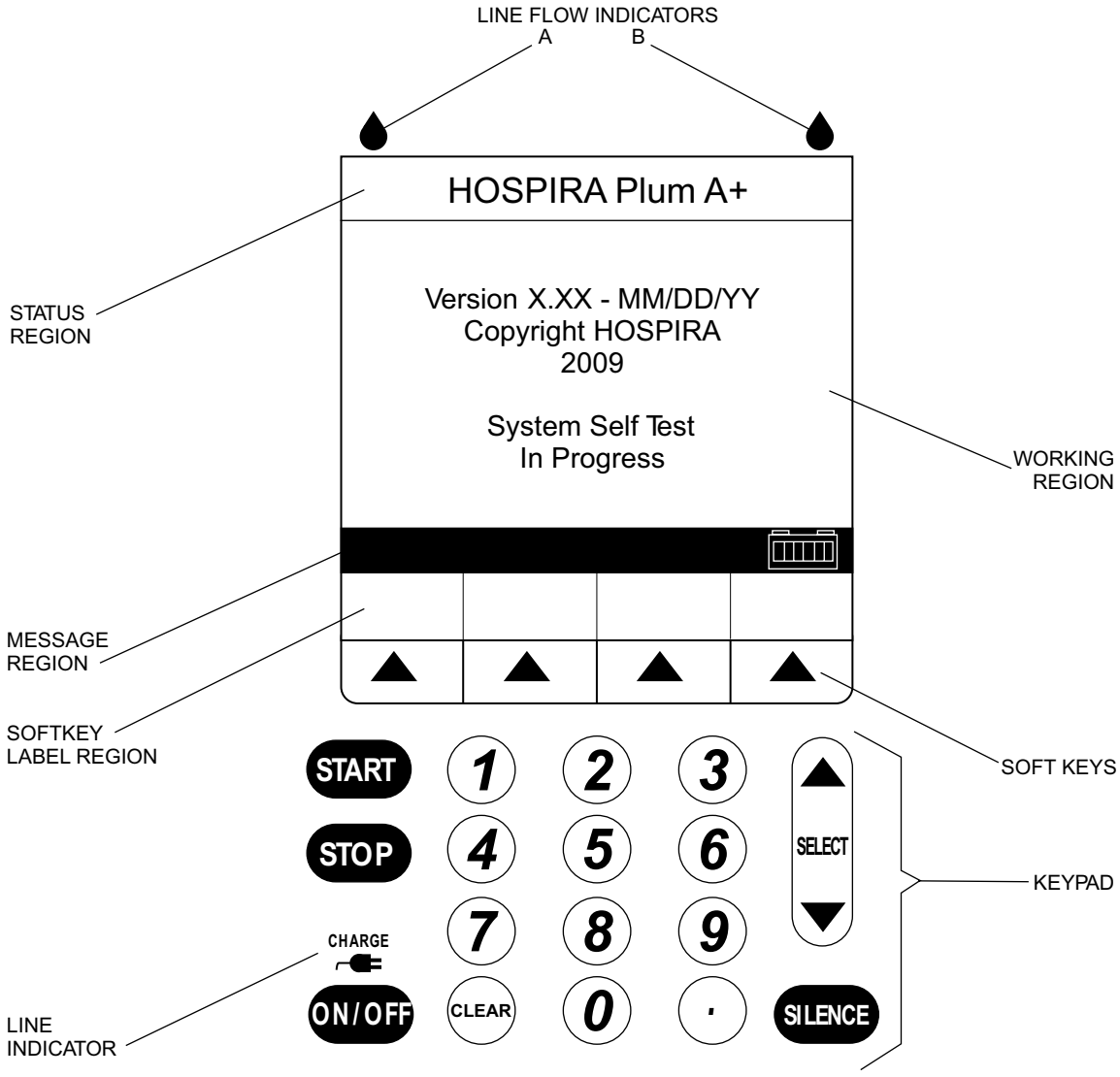


**Figure 5-1. Display and Keypad**

## 5.2.5
# CASSETTE ALARM TEST

To perform the cassette alarm test, proceed as follows:

1. Verify the infuser is on. Insert an empty cassette and close the door.
2. Verify the **CASSETTE TEST FAIL** message is flashing on the display and the alarm sounds after the cassette test is complete.
3. Open the door and remove the cassette.
4. Turn off the infuser.

## 5.2.6
# FREE FLOW TEST

To perform the free flow test, proceed as follows:

1. With a primed cassette installed, turn on the infuser.
2. If the **CLEAR SETTINGS?** message appears, press **[YES]**.
3. Place the distal end of tubing into a collection container a minimum of 36 inches below the cassette.
4. With the cassette door closed, check the distal end of the tubing for fluid flow. Verify a minimal flow of fluid occurs (a few drops maximum).
5. Open the cassette door and check the distal end of the tubing for fluid flow. Verify a minimal flow of fluid occurs (a few drops maximum).

   **Note:** A small amount of fluid may be expelled from the cassette when opening or closing the door.

6. Close the cassette door.

## 5.2.7
# DISPLAY TEST

To perform the display test, see *Figure 5-2*, and proceed as follows:

1. Verify the LCD backlight is illuminated and the display is clearly legible at eye level from approximately 18 inches.
2. With the infuser in the **PRIMARY** screen, press the **[OPTIONS/VOL INF]** softkey to select the **OPTIONS** screen.
3. Select **Lighting/Contrast**, and press **[CHOOSE]**.
4. Use the **[DECREASE SETTING]** and **[INCREASE SETTING]** softkeys to change backlight intensity. Verify intensity decreases and increases.
5. Select **Display Contrast**.
6. Press **[DECREASE SETTING]** and **[INCREASE SETTING]** to change display contrast. Verify the contrast decreases and increases.
7. Press the **[CANCEL]** softkey to return to the **OPTIONS** screen.
8. Press the **[BACK]** softkey to return to the **PRIMARY** screen.

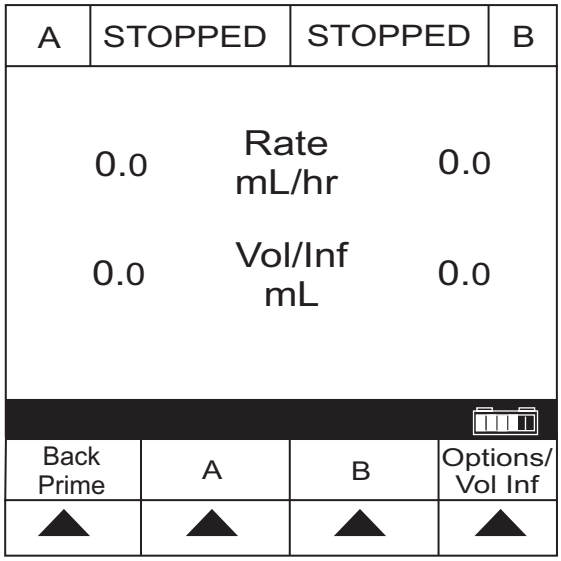


**Figure 5-2. Primary Screen**

## 5.2.8
# KEYPAD VERIFICATION/FUNCTIONAL TEST

To perform the keypad verification/functional test, see *Figure 5-1*, then proceed as follows:

1. With the infuser in the **PRIMARY** screen, press the [A] softkey to select line A.
2. Verify the **PROGRAM** screen is displayed.
3. Enter a rate of 123 mL/hr and VTBI of 4567 mL.
4. Press **[START]** and verify fluid is pumping, the message **PUMPING** is displayed in the line A status bar, and the line A LED flashes.
5. Press **[STOP]**, then press and hold the **[BACKPRIME]** softkey.
6. Verify the **BACKPRIMING** and **RELEASE BACKPRIME TO STOP** messages are displayed, and verify the infuser is actually backpriming.
7. Release the **[BACKPRIME]** softkey. Verify the **CASSETTE TEST IN PROGRESS** message appears, then press **[START]**, and verify normal pumping operation.
8. Press the **[B]** softkey. Verify **PIGGYBACK** is the displayed delivery mode. If necessary, change the delivery mode by pressing the **[CHANGE MODE]** softkey.
9. Enter a rate of 890 mL/hr and VTBI of 2 mL.
10. Press **[START]** and verify fluid is pumping, the message **PUMPING** is displayed in the line B status bar, and the line B LED flashes.
11. After approximately 20 seconds, verify pumping has switched to line A.
12. Press **[STOP]**.
13. Press **[OPTIONS/VOL INF]**. Select **Volume Infused**, and press **[CHOOSE]**.
14. Select line A.
15. Press **[CLEAR]**. Verify the line A volume is 0 mL and press [ENTER].

## 5.2.9
# ALARM LOUDNESS TEST

To perform the alarm loudness test, proceed as follows:

1. Press the **[A]** softkey to select line A.
2. Enter a rate of 400 mL/hr and VTBI of 1 mL.
3. Press **[START]** and verify fluid is pumping, the message **PUMPING** is displayed in the line A status bar, and the line A LED flashes.
4. Verify the alarm sounds when the dose has been delivered.
5. Turn the volume control knob between HIGH and LOW. Verify the alarm loudness changes *(see Figure 5-3)*.
6. Press **[SILENCE]**, and verify the alarm is silenced.
7. Press **[STOP]**.

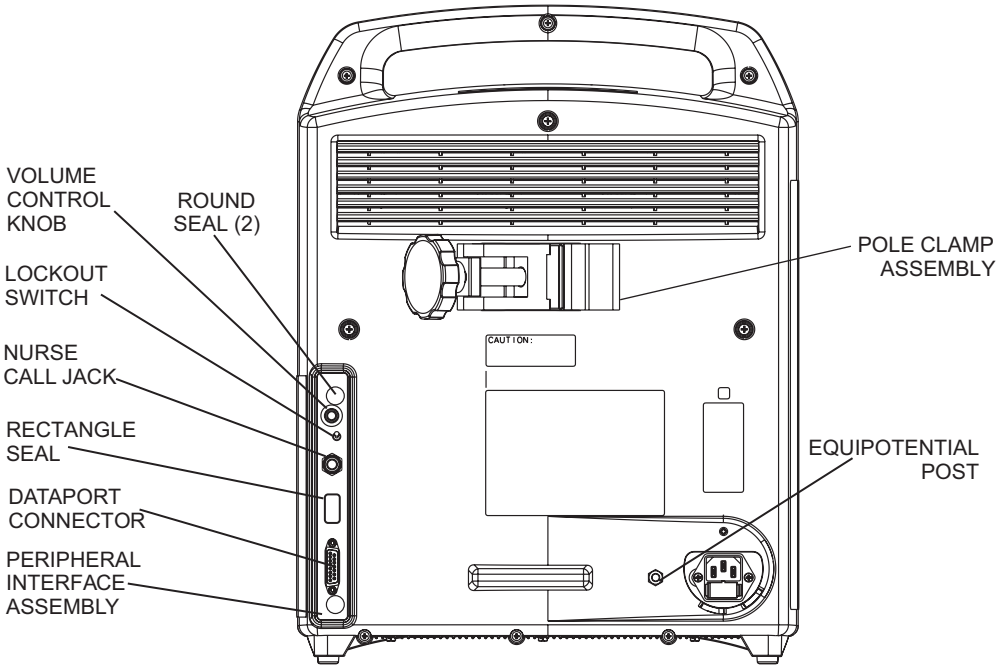


**Figure 5-3. Rear View**

## 5.2.10
# LOCKOUT SWITCH TEST

To perform the lockout switch test, proceed as follows:

1. Press the **[A]** softkey to select line A.
2. Enter a rate of 400 mL/hr and VTBI of 50 mL.
3. Press **[START]** and verify fluid is pumping, the message **PUMPING** is displayed in the line A status bar, and the line A LED flashes.
4. Toggle the lockout alarm switch up (ON) to engage the alarm *(see Figure 5-3)*.
5. Press any key except **[STOP]**, and verify an alarm sounds and the **HARD LOCKOUT ENABLED** message is displayed. Verify the infuser continues to operate until **[STOP]** is pressed.
6. Verify the **HARD LOCKOUT VIOLATION** message appears.
7. Toggle the lockout alarm switch down (OFF). Verify the **HARD LOCKOUT VIOLATION** message disappears and the alarm stops.
8. Press **[START]**.
9. Open the door and verify the **DOOR OPEN WHILE PUMPING** message is displayed and the audio alarm activates.
10. Close the cassette door.
11. Press **[NO]** at the **CLEAR SETTINGS?** prompt.

## 5.2.11
# PROXIMAL OCCLUSION TEST

To perform the proximal occlusion test, proceed as follows:

1. Press the **[A]** softkey to select line A.
2. Enter a rate of 400 mL/hr and VTBI of 50 mL.
3. Press **[START]** and verify fluid is pumping, the message **PUMPING** is displayed in the line A status bar, and the line A LED flashes.
4. After several pumping cycles, clamp line A tubing proximal to the cassette. Verify the **PROX OCCL A/AIR** message flashes and the alarm sounds before three pumping cycles are completed.
5. Press **[SILENCE]** and verify the alarm stops while the message on the display continues to flash.
6. Unclamp the proximal line and press **[START]**. Verify pumping resumes.
7. Press **[STOP]**.

## 5.2.12
# PROXIMAL AIR-IN-LINE TEST

To perform the proximal air-in-line alarm test, see *Figure 5-4*, then proceed as follows:

1. Install the special cassette marked **proximal**, and close the cassette door.

   **Note:** Confirm the special cassette proximal bubble sensor tips are removed.

2. Press **[YES]** to clear settings.
3. Press the **[A]** softkey to select line A.
4. Enter a rate of 400 mL/hr and VTBI of 50 mL.
5. Press **[START]** and verify fluid is pumping, the message **PUMPING** is displayed in the line A status bar, and the line A LED flashes.
6. Before 1 mL of fluid is delivered, verify the alarm sounds and the **PROX AIR A. BACKPRIME** message is flashing on the display.
7. Open the door, and remove the special cassette.

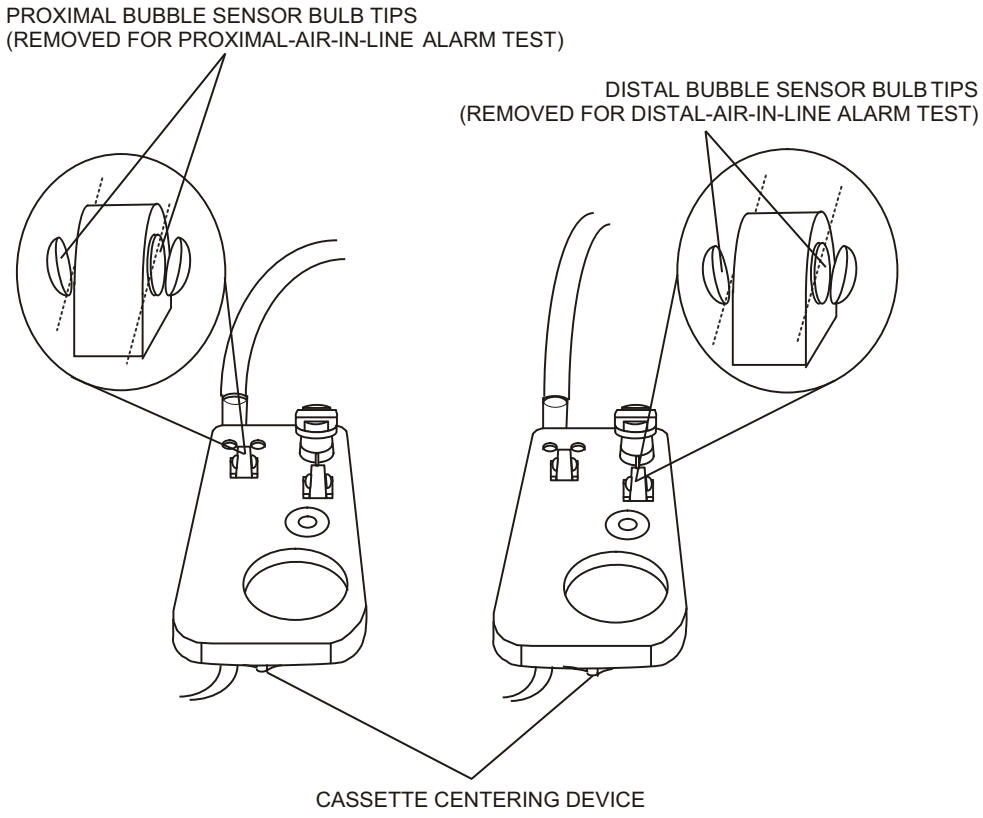
PROXIMAL BUBBLE SENSOR BULB TIPS
(REMOVED FOR PROXIMAL-AIR-IN-LINE ALARM TEST)
DISTAL BUBBLE SENSOR BULB TIPS
(REMOVED FOR DISTAL-AIR-IN-LINE ALARM TEST)
CASSETTE CENTERING DEVICE

**Figure 5-4. Special Cassettes with Bubble Sensor Tips Removed**

## 5.2.13
# DISTAL AIR-IN-LINE TEST

To perform the distal air-in-line alarm test, see *Figure 5-4*, then proceed as follows:

1. Install the special cassette marked **distal**, and close the cassette door.

   **Note:** Confirm the special cassette distal bubble sensor tips are removed.

2. Press **[YES]** to clear settings.
3. Press the **[A]** softkey to select line A.
4. Enter a rate of 400 mL/hr and VTBI of 50 mL.
5. Press **[START]** and verify fluid is pumping, the message **PUMPING** is displayed in the line A status bar, and the line A LED flashes.
6. Before 1 mL of fluid is delivered, verify the alarm sounds and the **DISTAL AIR A. BACKPRIME** message is flashing on the display.
7. Open the door, and remove the special cassette.

## 5.2.14
# DISTAL OCCLUSION TEST

To perform the distal occlusion test, see *Figure 5-5*, then proceed as follows:

1. Install a primed cassette and connect the distal tubing to the DPM through a three-way stopcock as illustrated in *Figure 5-5*. Close the cassette door.

   **Note:** A reflux valve may be attached between the stopcock and the DPM to keep moisture out of the DPM.

   **Note:** The height of the DPM must be 0 ± 12 inches from the midline of the pumping chamber.

2. Turn on the infuser.
3. Press **[YES]** to clear settings.
4. Press **[OPTIONS/VOL INF]** to select the **OPTIONS** screen.
5. Select **Pressure/Post Infusion Rate**, and press **[CHOOSE]**.
6. Verify continue rate is set to KVO, and distal pressure limit is set at 6 psi. If the pressure limit is not 6 psi, enter **6** and press **[ENTER]**.
7. Press the **[A]** softkey to select line A.
8. Enter a rate of 40 mL/hr and VTBI of 50 mL.
9. Open the three-way stopcock to air.
10. Press **[START]** and verify fluid is pumping, the message **PUMPING** is displayed in the line A status bar, and the line A LED flashes.
11. Set the three-way stopcock to measure pressure.
12. Verify the distal occlusion audible alarm occurs at 6 ± 3 psi. Verify the **DISTAL OCCLUSION** message is flashing on the screen.
13. Open the three-way stopcock to air. Verify the DPM is zeroed.

14. Open and close the door. Press **[NO]** at the **CLEAR SETTINGS?** prompt.
15. Press **[OPTIONS/VOL INF]** to select the **OPTIONS** screen.
16. Select **Pressure/Post Infusion Rate**, and press **[CHOOSE]**.
17. Select **Distal Pressure Limit**. Enter 10 psi, and press **[ENTER]**.
18. Set the three-way stopcock to measure pressure, then press **[START]**.
19. Verify the distal occlusion audible alarm occurs at 10 ± 3 psi. Verify the **DISTAL OCCLUSION** message is flashing on the screen.
20. Open the door and remove the cassette.

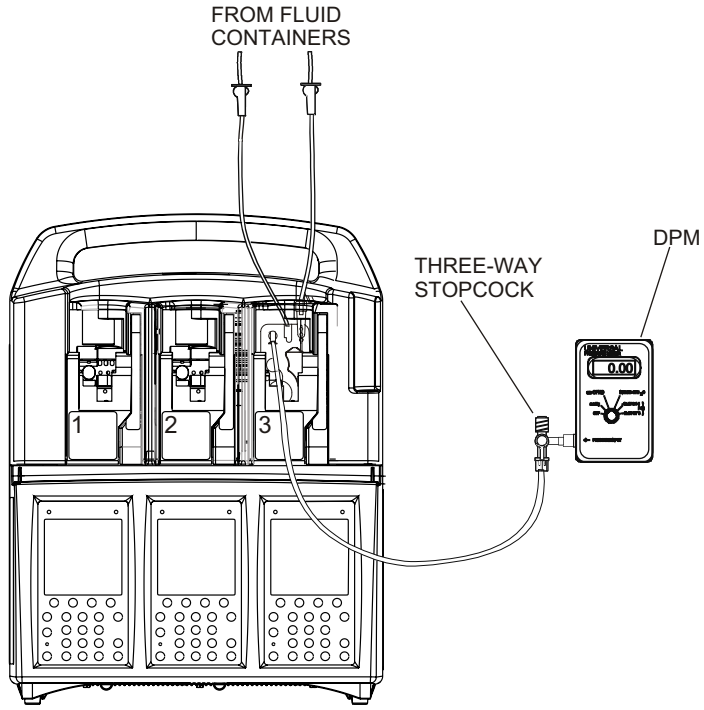


**Figure 5-5. Distal Occlusion Test Setup**

## 5.2.15
# DELIVERY ACCURACY TEST

**Note:** Accuracy testing is for informational purposes only, and is not to be used as a re-release test. If there is any concern as to infuser accuracy, contact Hospira.

**CAUTION: Do not remove the protective cover from the 21-gauge needle.**

To perform the delivery accuracy test, proceed as follows:

1. Open the cassette door and insert a primed cassette. Close the cassette door.
2. Press **[YES]** to clear settings.
3. Install an 18-gauge blunt cannula or a 21-gauge needle to the distal end of the tubing. Verify the fluid container is approximately 18 to 24 inches above the pumping chamber. Verify all lines are unclamped.
4. Place the distal output end of tubing into the graduated cylinder.
5. Press the **[A]** softkey to select line A.
6. Enter a rate of 200 mL/hr and VTBI of 10 mL.
7. Press **[START]** and verify fluid is pumping, the message **PUMPING** is displayed in the line A status bar, and the line A LED flashes.
8. Press the **[B]** softkey to select line B.
9. Verify the infuser is in the **PIGGYBACK** delivery mode. If necessary, press **[CHANGE MODE]** to change the delivery mode.
10. Enter a rate of 200 mL/hr and VTBI of 10 mL.
11. Press **[START]** and verify fluid is pumping, the message **PUMPING** is displayed in the line B status bar, and the line B LED flashes.
12. Verify the **KVO** message flashes on the display and an audible alarm sounds when total delivery is complete on line A.
13. Press **[STOP]** and verify the volume delivered is 20 ± 1 mL.

## 5.2.16
# NURSE CALL TEST

**Note:** The nurse call test may be bypassed if the nurse call function is not used.

To perform the nurse call test, attach the nurse call test cable and proceed as follows:

1. Set the primary delivery rate to 400 mL/hr, and the primary dose limit to 1 mL.
2. Connect the DMM to the nurse call test cable.
3. Press **[START]** and verify pumping action.
4. After **DOSE END** and **KVO** appear on the display, observe a short circuit on the DMM (approximately 1 Ω on a scale of 0 to 100 Ω).

## 5.2.17
# ELECTRICAL SAFETY TEST

**Note:** The electrical safety test must be performed in accordance with the instructions contained in the safety analyzer user's guide.

To perform the electrical safety test, proceed as follows:

1. Connect the AC power cord to the safety analyzer.
2. Connect the safety analyzer ground lead to the device equipotential post.
3. Test the enclosure and earth leakage currents under normal and single fault conditions. See *Table 5-2* for electrical safety measurements.
4. Measure the resistance of the AC connector ground lug and exposed metal parts *(see Table 5-2)*.

**Table 5-2. Electrical Safety Measurements**

| Measurement | Not to Exceed |
|---|---|
| Enclosure leakage current normal condition (ground intact) | 0.1 mA |
| Enclosure leakage current (open) | 0.5 mA |
| Earth leakage current (ground intact) | 0.5 mA |
| Earth leakage current (open ground) | 1 mA |
| Chassis ground resistance | 0.2 Ω |

### 5.2.18
## END OF THE PVT

If all performance verification tests have been successful, proceed as follows:

1. Press **[OPTIONS/VOL INF]**. Select **Volume Infused**, and press **[CHOOSE]**.
2. Press **[CLEAR]** to clear the volume infused, then press **[ENTER]**.
3. Press the **[A]** softkey. Press the **[CLEAR PROGRAM]** softkey.

   **Note:** **[CLEAR PROGRAM]** will appear only if there is a program in the A or B channel.
4. Press **[YES]** at the **CLEAR LINE A SETTINGS?** prompt.
5. Press [**CANCEL/BACK]** to return to the delivery screen.
6. Press the **[B]** softkey. Press the **[CLEAR PROGRAM]** softkey.

   **Note:** **[CLEAR PROGRAM]** will appear only if there is a program in the A or B channel.
7. Press **[YES]** at the **CLEAR LINE B SETTINGS?** prompt
8. Reset the infuser to the original configuration.
9. Turn off the infuser and return the device to service.

**Note:** If any tests fail, see *Section 6*, or contact Hospira.

## 5.3
# PERIODIC MAINTENANCE INSPECTION

Periodic maintenance inspections should be performed per hospital procedures for compliance to accreditation requirements. It is recommended that JCAHO and/or hospital protocol be followed for establishing a periodic maintenance inspection schedule. Product specifications for this inspection are listed in *Section 8*.

To perform the periodic maintenance inspection, complete the PVT in *Section 5.2*.

# 5.4
# BATTERY OPERATION OVERVIEW

The infusion system is intended to operate on battery power on an exception basis only, such as emergency backup or temporary portable operation. Examples of emergency backup include AC power failure or inadvertent disconnection of the AC power cord. An instance of temporary portable operation includes patient transfer from one location to another.

The device should be connected to AC power whenever possible to allow the battery to remain fully charged. The line power indicator turns off when the infuser is operating on battery power. The backlight extinguishes after approximately one minute of operation on battery power.

Factors that most commonly affect battery life are the depth and frequency of discharge and the length of the recharge period. As a general rule, the more often the battery is discharged and recharged, the sooner it will need replacement.

The primary cause of damage is leaving the battery in a less than fully charged state for any period of time. Battery damage can occur in a matter of hours and cause a permanent loss of battery capacity. The amount of lost capacity depends on the degree of discharge, the storage temperature, and the length of time the battery was stored in a discharged state.

**Note:** A permanently damaged battery cannot be recharged to full capacity.

When the battery discharges below the acceptable level while the infuser is operating, the audio indicator is activated and the “WARNING: LOW BATTERY” message displays. Although it is not recommended to continue operating the infuser on battery power at this point, the battery continues providing power until it is depleted. When the battery is depleted, delivery stops, a continuous alarm tone sounds, and, after three minutes, the infuser automatically turns off.

**CAUTION: As soon as the low battery alarm occurs, connect the infuser to AC power.**

When the infuser detects that the battery has reduced capacity, it will register a **Replace Battery** condition. For the first two occurrences of a **Replace Battery** condition, the **WARNING: LOW BATTERY** message will appear and the audio indicator will activate. The message and audio indicator can be cleared only when the device is plugged in or turned off. For the third and subsequent occurrences, the **WARNING: REPLACE BATTERY** message will appear, and the audio indicator will activate and persist over power cycles.

The message and audio indicator are cleared by replacing the battery, accessing the **Biomed Settings** screen, and pressing the **[CHANGE BATTERY]** softkey.

Recharging can occur any time the infuser is connected to AC power. It is recommended that the infuser be connected to AC power whenever practical to maximize available battery charge during transport or ambulation. The infuser does not have to be on for the battery to recharge.

**Note:** The infuser should be operated on battery power for three continuous hours at least once every six months for optimum battery performance and life.

Section 6

# TROUBLESHOOTING

This section contains information on technical assistance, warning messages, alarm messages and error codes, and troubleshooting procedures.

## 6.1 TECHNICAL ASSISTANCE

For technical assistance, product return authorization, and to order parts, accessories, or manuals within the United States, contact Hospira.

**1-800-241-4002**

For additional technical assistance, technical training, and product information, visit the website at **www.hospira.com**.

Send all authorized, prepaid returns within the United States to the following address:

**Hospira, Inc.**
**Technical Support Operations**
**755 Jarvis Drive**
**Morgan Hill, California 95037**

For technical assistance, product return authorization, and to order parts, accessories, or manuals from outside the United States, contact the nearest Hospira sales office.

## 6.2 WARNING MESSAGES

*Table 6-1* lists warning messages, possible causes, and corrective actions. These warning messages are captured in the Error Log.

**Note:** When the infuser detects that the battery has reduced capacity, it will register a **Replace Battery** condition. For the first two occurrences of a **Replace Battery** condition, the **WARNING: LOW BATTERY** message will appear and the audio indicator will activate. The message and audio indicator can be cleared only when the device is plugged in or turned off. For the third and subsequent occurrences, the **WARNING: REPLACE BATTERY** message will appear, and the audio indicator will activate and persist over power cycles. The message and audio indicator are cleared by replacing the battery, accessing the **Biomed Settings** screen, and pressing the **[CHANGE BATTERY]** softkey.

**Note:** If the device is not plugged in, and turned on with a previously depleted battery, the infuser will display a **DEPLETED BATTERY** message for 12 seconds ± 3 seconds, then power off.

| Table 6-1. Warning Messages | | |
|---|---|---|
| **Message** | **Possible Cause** | **Corrective Action** |
| **Stop delivery, then turn off** | Attempting to turn off the infuser while a delivery is in progress | Stop all lines, then turn off the infuser |
| **Warning: Low Battery** | Battery is discharged so that only approximately 30 minutes of battery life remain | Plug into AC power |
| **Warning: Replace Battery** | Battery service needed<br>Battery voltage is less than the depleted threshold and the charge level is higher than the low charge threshold | Replace the battery *(see Section 7.2.4)* |
| **Warning: Charger Service** | A hardware problem with the battery charging circuit is detected<br>Charging circuitry is not behaving as expected | Press **[SILENCE]** |

## 6.3
# ALARM MESSAGES AND ERROR CODES

Under most alarm conditions the infuser ceases normal operation, generates an audible alarm, and displays an alarm message or error code on the LCD screen.

There are two types of alarm conditions:

- alarm codes that can be cleared by the operator
- error codes that require qualified service personnel

### 6.3.1
## OPERATIONAL ALARM MESSAGES

*Table 6-2* lists infuser alarm codes that can be cleared by the operator. Also listed in *Table 6-2* are the alarm messages, descriptions, possible causes, and corrective actions.

**Note:** Operational alarm messages are displayed on the LCD screen. Associated error codes are displayed in the Alarms Log *(see Section 1.8.2)*.

**Table 6-2. Operational Alarm Messages and Corrective Actions**

| Alarm Code | Alarm | Description | Possible Cause | Corrective Action |
|---|---|---|---|---|
| **N100** (URC) | Unrecognizable cassette | Incorrect cassette type | An incorrect cassette is inserted | Insert proper cassette |
| **N101** (NAA) | No action | No operator action and no delivery for two minutes during delivery parameters entry | Interruption or a partial change to a program | Complete programming |
| **N102** (RL) | Infuser idle 2 minutes | Infuser in reset or idle for over two minutes | Programming set without start for two minutes | Press **[START]** |
| **N103** (SEEP CRC) | NV RAM lost thrpy data | Therapy data is lost | Infuser did not complete the previous non-volatile memory write successfully | Re-enter all programmed data |
| **N104** (NC2) | Nurse callback B | Delivery line B has changed (if alarm is enabled) | End of delivery step on line B other than VTBI complete while callback is enabled | Press **[SILENCE]** |
| **N105** (NC1) | Nurse callback A | Delivery line A has changed (if alarm is enabled) | End of delivery step on line A other than VTBI complete while callback is enabled | Press **[SILENCE]** |
| **N160** or **E160** (VTB2) | Line B VTBI complete | Programmed VTBI completed on line B | VTBI complete on line B | Press **[SILENCE]**, replace IV bag, and restart line B |
| **N161** or **E161** (VTB1) | Line A VTBI complete | Programmed VTBI completed on line A | VTBI complete on line A | Press **[SILENCE]**, replace IV bag, and restart line A |
| **N180** or **E180** (OD1) | Distal Occl | Peak distal occlusion, non-delivery | Distal occlusion detected during non-delivery | Backprime the cassette and restart the infuser |
| **N181** or **E181** (OD1) | Distal Occl | Negative distal occlusion, non-delivery | Distal occlusion detected during non-delivery | Backprime the cassette and restart the infuser |
| **N182** or **E182** (OP2) | Prox. Occl B, Air or Prox. Occl B | Negative proximal occlusion B, non-delivery | Proximal occlusion detected on line B during non-delivery | Backprime the cassette and restart line B<br>or<br>Stop all lines, backprime the cassette, and restart all lines |

**Table 6-2. Operational Alarm Messages and Corrective Actions**

| Alarm Code | Alarm | Description | Possible Cause | Corrective Action |
|---|---|---|---|---|
| **N183** or **E183** (OP2) | Prox. Occl B, Air or Prox. Occl B | Peak proximal occlusion B, non-delivery | Proximal occlusion detected on line B during non-delivery | Backprime the cassette and restart line B or Stop all lines, backprime the cassette, and restart all lines |
| **N184** or **E184** (OP1) | Prox. Occl A, Air or Prox. Occl A | Negative proximal occlusion A, non-delivery | Proximal occlusion detected on line A during non-delivery | Backprime the cassette and restart line A or Stop all lines, backprime the cassette, and restart all lines |
| **N185** or **E185** (OP1) | Prox. Occl A, Air or Prox. Occl A | Peak proximal occlusion A, non-delivery | Proximal occlusion detected on line A during non-delivery | Backprime the cassette and restart line A or Stop all lines, backprime the cassette, and restart all lines |
| **N186** or **E186** (OD1) | Distal Occl | Peak distal occlusion, delivery | Distal occlusion detected during delivery | Fix occlusion and restart the infuser |
| **N187** or **E187** (OD1) | Distal Occl | Negative distal occlusion, delivery | Distal occlusion detected during delivery | Fix occlusion and restart the infuser |
| **N188** or **E188** **(**OP2) | Prox. Occl B, Air | Negative proximal occlusion B, delivery | Proximal occlusion detected during delivery on line B | Fix occlusion and restart line B or Stop all lines, fix occlusion and restart the infuser |
| **N189** or **E189** (OP2) | Prox. Occl B, Air | Peak proximal occlusion B, delivery | Proximal occlusion detected during delivery on line B | Fix occlusion and restart line B or Stop all lines, fix occlusion and restart the infuser |
| **N190** or **E190** (OP1) | Prox. Occl A, Air | Negative proximal occlusion A, delivery | Proximal occlusion detected during delivery on line A | Fix occlusion and restart line A or Stop all lines, fix occlusion and restart the infuser |

**Table 6-2. Operational Alarm Messages and Corrective Actions**

| Alarm Code | Alarm | Description | Possible Cause | Corrective Action |
|---|---|---|---|---|
| **N191** or **E191** (OP1) | Prox. Occl A, Air | Peak proximal occlusion A, delivery | Proximal occlusion detected during delivery on line A | Fix occlusion and restart line A or Stop all lines, fix occlusion and restart the infuser |
| **N230** or **E230** (APT) | Prox. Air Total | Proximal air-in-line total | 500 µL of air has entered the cassette | Backprime the cassette and restart the infuser or Remove and manually reprime the cassette, and restart the infuser |
| **N231** or **E231** (APB) | Prox. Air on B, backprime | Proximal air-in-line on line B | 500 µL of air has entered the cassette on line B | Backprime the cassette and restart line B or Remove and manually reprime the cassette and restart the infuser |
| **N232** or **E232** (APA) | Prox. Air on A, backprime | Proximal air-in-line on line A | 500 µL of air has entered the cassette on line A | Backprime the cassette and restart line A or Remove and manually reprime the cassette and restart the infuser |
| **N233** or **E233** (ADC) | Distal air cumulative | Distal air cumulative | 500 µL of air detected in the last 5.3 mL of fluid delivered | Remove and manually reprime the cassette and restart the infuser |
| **N234** or **E234** (ADB) | Distal air bolus | Distal air bolus | 100 µL bolus of air detected at distal sensor | Remove and manually reprime the cassette and restart the infuser |
| **N250** or **E250** (DCO1) | Door opened while pumping | Door opened while pumping | Door opened while pumping | Turn off the infuser or Insert the cassette and close the door |
| **N251** or **E251** (CS1) | Valve/cass test fail | Valve/cassette test failure | Valve/cassette fails leak test | Backprime and retest or Replace the cassette and retest or Replace the mechanism |

**Table 6-2. Operational Alarm Messages and Corrective Actions**

| Alarm Code | Alarm | Description | Possible Cause | Corrective Action |
|---|---|---|---|---|
| **N252** or **E252** (BDP) | Depleted battery | Low battery | Battery terminal voltage is less than 5.45 V | Connect the infuser to AC power or Recharge or replace the battery |
| **N253** or **E253** (LOV) | Lockout violation | Hard lockout violation | The use of the **[STOP]** key or an attempt to open the door while lockout switch is locked | Unlock the lockout switch |
| **N254** or **E254** (FPL) | Lockout Enabled | Keypad locked | Any action not resulting in stopping of delivery while lockout switch is locked | Unlock the lockout switch |
| **N255** (SLV) | Lockout violation | Soft lockout violation | The use of the **[STOP]** key or an attempt to open the door while lockout switch is locked | Unlock the software lockout switch |
| **N256** (SLE) | Lockout enabled | Soft lockout enabled | Any action not resulting in stopping of delivery while lockout switch is locked | Unlock the software lockout switch |

## 6.3.2
# ERROR CODES REQUIRING TECHNICAL SERVICE

*Table 6-3* lists infusion system error codes that require technical service. Also listed in *Table 6-3* are malfunction descriptions, possible causes, and corrective actions.

**Table 6-3. Error Codes Requiring Technical Service**

| Error Code | Malfunction | Possible Cause | Corrective Action |
|---|---|---|---|
| **E300** | ADC failure | Analog to digital converter failure | Replace CPU PWA *(see Section 6)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E301** | Audio alarm failure | Piezo is off but sensed on<br>or<br>Piezo is on but sensed off | Turn power off, then on, to reset the infuser<br>Replace piezo alarm *(see Section 7.2.14.7)*<br>Replace CPU PWA *(see Section 7.2.14.6)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E302** | Backlight failure | Backlight (CCFT tube) is not at the expected range | Turn power off, then on, to reset the infuser<br>Replace display *(see Section 7.2.14.3)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E320** | Battery charge current out of range | Battery charge current is out of range after 8 hours | Replace battery *(see Section 7.2.4)*<br>Replace power supply PWA *(see Section 7.2.14.1)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E321** | Battery not charging | Battery charging timed out<br>Complete battery discharge has occurred | Charge battery for additional eight hours<br>Replace battery *(see Section 7.2.4)*<br>Replace power supply PWA *(see Section 7.2.14.1)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E322** | Battery current calibration value out of range | Battery integrator calibration value is out of range | |
| **E323** | Battery trickle charge current out of range | Battery trickle charge current is out of range | |
| **E324** | Supply overvoltage | An overvoltage condition is detected in the charging circuit | |
| **E325** | Battery overvoltage | An overvoltage condition is detected in the battery | |

**Table 6-3. Error Codes Requiring Technical Service**

| Error Code | Malfunction | Possible Cause | Corrective Action |
|---|---|---|---|
| **E326** | Battery disconnected | Battery disconnected while the infuser is on | Check for loose battery connections<br>Replace battery *(see Section 7.2.4)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E327** | Brownout condition | Brownout condition detected | Replace power supply PWA *(see Section 7.2.14.1)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E340** | Critical instruction failure | Power-up CPU register test failed (no malfunction message displayed) | Replace CPU PWA *(see Section 7.2.14.6)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E341** | Critical data memory failure | Critical data memory failure | Replace mechanism assembly *(see Section 7.2.14.8)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E342** | Display failure | Defective display | Replace display *(see Section 7.2.14.3)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E343** | Distal air sensor failure 1 | With the cassette removed, the distal air sensor self test detects liquid | Replace mechanism assembly *(see Section 7.2.14.8)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E344** | Distal air sensor failure 2 | With the cassette inserted, the distal air sensor self test detects sensor out of range | |
| **E345** | Distal pressure sensor failure 1 | Distal pressure sensor failed while the infuser is off | |
| **E346** | Distal pressure sensor failure 2 | Distal pressure sensor failed while the infuser is on | |
| **E347** | Hardware watchdog failure | Hardware watchdog failure | Replace CPU PWA *(see Section 7.2.14.6)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E378** | I/O valve phase loss | Generic I/O valve failure | Turn power off, then on, to reset the infuser<br>Replace mechanism assembly *(see Section 7.2.14.8)*<br>Reset time and date, if required *(see Section 1.8.3)* |

**Table 6-3. Error Codes Requiring Technical Service**

| Error Code | Malfunction | Possible Cause | Corrective Action |
|---|---|---|---|
| **E379** | L/S valve phase loss | Generic L/S valve failure | Turn power off, then on, to reset the infuser<br>Replace mechanism assembly *(see Section 7.2.14.8)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E380** | Plunger motor phase loss | Generic plunger motor failure | |
| **E430** | Proximal air sensor failure 1 | Proximal air sensor ongoing test detects liquid with cassette removed | Replace mechanism assembly *(see Section 7.2.14.8)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E431** | Proximal air sensor failure 2 | Proximal air sensor self test detects liquid with cassette removed | |
| **E432** | Proximal pressure sensor 1 | Proximal pressure sensor failed while the infuser is off | |
| **E433** | Proximal pressure sensor 2 | Proximal pressure sensor failed while the infuser is on | |
| **E434** | RAM failure | RAM failure | Turn power off, then on, to reset the infuser<br>Replace peripheral assembly *(see Section 7.2.7)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E435** | RTC failure | Real-time clock failure | Turn power off, then on, to reset the infuser<br>Replace CPU PWA *(see Section 7.2.14.6)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| E436 | ROM failure | ROM checksum failure | Turn power off, then on, to reset the infuser<br>Replace peripheral assembly *(see Section 7.2.7)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E437** | Software failure | Generic software failure | Turn power off, then on, to reset the infuser<br>Replace CPU PWA *(see Section 7.2.14.6)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E438** | Stack out-of-range failure | Stack out-of-range failure | |
| **E439** | Stuck key | A key is sensed as pressed for over two minutes | Replace keypad *(see Section 7.2.14.2)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E440** | Power hold stuck | Power hold signal stuck<br>Power cannot be turned off | |

**Table 6-3. Error Codes Requiring Technical Service**

| Error Code | Malfunction | Possible Cause | Corrective Action |
|---|---|---|---|
| **E443** | LCD failure | LCD bias is out of range | Replace display assembly *(see Section 7.2.14.3)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E444** | CPU timebase inaccurate | CPU timer 2 and RTC measured times disagree | Turn power off, then on, to reset the infuser<br>Replace CPU PWA *(see Section 7.2.14.6)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E445** | RTC memory failure | Real-time clock memory is corrupt | Turn power off, then on, to reset the infuser<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E446** | CPU timer failure | CPU timer 1 and timer 2 measured times disagree | Replace CPU PWA *(see Section 7.2.14.6)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E447** | Battery ADC reading failure | 16 consecutive readings have been either all zero or the max value | |
| **E448** | SEEP write failure | SEEP data write failed | Replace mechanism assembly *(see Section 7.2.14.8)*<br>Replace CPU PWA *(see Section 7.2.14.6)*<br>Replace CPU/driver cable *(see Section 7.2.14.4)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E449** | SEEP calibration data corrupted | Calibration data block corrupted | |
| **E450** | MMIO port read/write failure | I/O port read/write failure | Replace CPU PWA *(see Section 7.2.14.6)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E451** | Inaccurate delivery | Over/under delivery detected | Turn power off, then on, to reset the infuser<br>Reset time and date, if required *(see Section 1.8.3)*<br>If error codes recur, contact Hospira |
| **E452** | Software failure | Miscellaneous software failures | |
| **E453** | Two SEEP CRC errors | NVRAM data block corrupted | Replace mechanism assembly *(see Section 7.2.14.8)*<br>Replace CPU PWA *(see Section 7.2.14.6)*<br>Replace CPU/driver cable *(see Section 7.2.14.4)*<br>Reset time and date, if required *(see Section 1.8.3)* |
| **E454** | NVRAM over capacity | Software trying to write into non-existent NVRAM space | |

| Table 6-3. Error Codes Requiring Technical Service | | | |
|---|---|---|---|
| **Error Code** | **Malfunction** | **Possible Cause** | **Corrective Action** |
| **E455** | Invalid device configuration | Incorrect flash memory on peripheral PWA | Turn power off, then on, to reset the infuser<br>Replace peripheral PWA *(see Section 7.2.8)* |
| **E456** | Invalid drug library | A drug library install was started but not completed successfully | Attempt to reinstall the drug library *(see the System Operating Manual)*<br>Replace peripheral assembly *(see Section 7.2.7)* |
| **E457** | Drug library corrupted | CRC failure on drug library | Reload the library *(see the System Operating Manual)* |

The following error codes are not generated in the Biomed service mode:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **E320** | **E323** | **E326** | **E346** | **E373** | **E376** | **E379** | **E431** | **E441** |
| **E321** | **E324** | **E343** | **E371** | **E374** | **E377** | **E380** | **E432** | **E447** |
| **E322** | **E325** | **E345** | **E372** | **E375** | **E378** | **E430** | **E433** | |

**Note:** Some error codes include sub-ID codes. These sub-ID codes are intended for Hospira internal use only, and should be included when contacting Hospira.

# 6.4 TROUBLESHOOTING PROCEDURES

This section details recommended procedures for problems not associated with malfunction alarms.

Before performing any troubleshooting procedure, turn the infuser off, then on.

Allow the self test to complete and proceed as follows:

1. If a malfunction exists, carefully inspect the infuser for damage as described in *Section 5.2.2*.
2. If an infuser inspection has not disclosed a malfunction, perform the PVT in *Section 5.2*. See *Table 6-4* for section reference, probable cause, and corrective actions.
3. If, after completing step 1 and step 2, a malfunction has not been located, or if the infuser persistently fails, contact Hospira.

**Table 6-4. Troubleshooting with the PVT**

| Test Failure | Probable Cause | Corrective Action |
|---|---|---|
| **Self Test** *Section 5.2.4* | Cassette not properly installed | Reseat cassette |
| | Defective CPU PWA | Replace CPU PWA *(see Section 7.2.14.6)* |
| **Cassette Alarm Test** *Section 5.2.5* | Cassette not properly seated | Reseat cassette |
| | Defective cassette | Replace cassette |
| **Free Flow Test** *Section 5.2.6* | Cassette not properly seated | Reseat cassette |
| | Defective cassette | Replace cassette |
| | Defective or dirty valve pins | Clean valve pins |
| | | Replace mechanism assembly *(see Section 7.2.14.8)* |
| **Display Test** *Section 5.2.7* | Defective display assembly | Replace display assembly *(see Section 7.2.14.3)* |
| **Keypad Verification/Functional Test** *Section 5.2.8* | Defective keypad | Replace keypad *(see Section 7.2.14.2)* |
| **Alarm Loudness Test** *Section 5.2.9* | Defective CPU | Replace CPU PWA *(see Section 7.2.14.6)* |
| | Defective peripheral PWA | Replace peripheral PWA *(see Section 7.2.8)* |
| | Defective piezo alarm assembly | Replace piezo alarm assembly *(see Section 7.2.14.7)* |
| **Lockout Switch Test** *Section 5.2.10* | Defective peripheral PWA | Replace peripheral PWA *(see Section 7.2.8)* |
| **Proximal Occlusion Test** *Section 5.2.11* | Closed proximal clamp | Open clamp |
| | Cassette not properly primed | Re-prime cassette |
| | Defective cassette | Replace cassette |
| | Dirty sensor pin | Clean sensor pin |
| | Defective APP PWA | Replace mechanism assembly *(see Section 7.2.14.8)* |
| **Proximal Air-in-Line Test** *Section 5.2.12* | Defective special cassette | Replace special cassette |
| | Dirty sensors | Clean sensors |
| | Defective APP PWA | Replace mechanism assembly *(see Section 7.2.14.8)* |
| **Distal Air-in-Line Test** *Section 5.2.13* | Defective special cassette | Replace special cassette |
| | Dirty sensors | Clean sensors |
| | Defective APP PWA | Replace mechanism assembly *(see Section 7.2.14.8)* |

**Table 6-4. Troubleshooting with the PVT**

| Test Failure | Probable Cause | Corrective Action |
|---|---|---|
| **Distal Occlusion Test** *Section 5.2.14* | Cassette not properly primed | Re-prime cassette |
| | Defective cassette | Replace cassette |
| | Dirty sensor pin | Clean sensor pin |
| | Defective APP PWA | Replace mechanism assembly *(see Section 7.2.14.8)* |
| **Delivery Accuracy Test** *Section 5.2.15* | Set not properly primed | Re-prime cassette |
| | Damaged or faulty cassette | Replace cassette |
| | Defective mechanism assembly | Replace mechanism assembly *(see Section 7.2.14.8)* |
| **Electrical Safety Test** *Section 5.2.16* | Defective AC power cord | Replace AC power cord *(see Section 7.2.5)* |

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Section 7

# REPLACEABLE PARTS AND REPAIRS

This section itemizes all parts and subassemblies of the infusion system that are repairable within the scope of this manual. In addition, this section details replacement procedures for all listed parts.

## 7.1 REPLACEABLE PARTS

Replaceable parts for the infusion system are itemized in the Illustrated Parts Breakdown (IPB) and are identified in *Figure 9-1*. *Table 9-2* identifies each part by an index number that correlates to *Figure 9-1*.

To view the online replacement parts list, visit the website at **www.hospiraparts.com**.

## 7.2 REPLACEMENT PROCEDURES

This section contains safety and equipment precautions, required tools and materials, and step-by-step procedures for replacing parts in the infuser. Unless otherwise stated, always perform the PVT after a replacement procedure.

**Note:** Figures are rendered as graphic representations to approximate actual product. Therefore, figures may not exactly reflect the product.

### 7.2.1 SAFETY AND EQUIPMENT PRECAUTIONS

Before opening the front enclosure of the infuser, take all necessary precautions for working on high-voltage equipment.

**WARNING: EXPLOSION HAZARD EXISTS IF THE INFUSER IS SERVICED IN THE PRESENCE OF FLAMMABLE SUBSTANCES.**

**WARNING: UNLESS OTHERWISE INDICATED, DISCONNECT THE INFUSER FROM AC POWER BEFORE PERFORMING REPLACEMENT PROCEDURES.**

**CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store PWAs in antistatic bags before placing them on any surface.**

## 7.2.2
# REQUIRED TOOLS AND MATERIALS

The following tools and materials, or equivalents, are required for the replacement procedures in this section. In addition, the beginning of each procedure lists tools and materials required for that specific procedure.

- Set of flat blade screwdrivers
- Set of Phillips screwdrivers
- Set of standard and metric nutdrivers
- Metric 10 mm wrench
- Custom nutdriver (P/N 519-95056-001)
- Long needle nose pliers
- Wide head pliers
- Diagonal cutters
- X-acto® knife
- Mild solvent
- Lint-free cloth

## 7.2.3
# RUBBER FOOT PAD REPLACEMENT

The recommended tool for this procedure is a #2 Phillips screwdriver.

Replacement parts for this procedure are:

**Pad, Rubber Foot**
**Screw, 6-32 x 1/2, Pan Head, Phillips**

To replace a rubber foot pad see *Figure 7-1*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Place the infuser face down on a soft flat surface.
3. Using the Phillips screwdriver, remove the screw that secures the rubber foot pad.
4. Install the replacement rubber foot pad in the exact reverse order of removal.

Replacement of a rubber foot pad is routine maintenance and no verification procedure is normally required. However, if the infuser may have been damaged during the procedure, perform the PVT in *Section 5.2*.

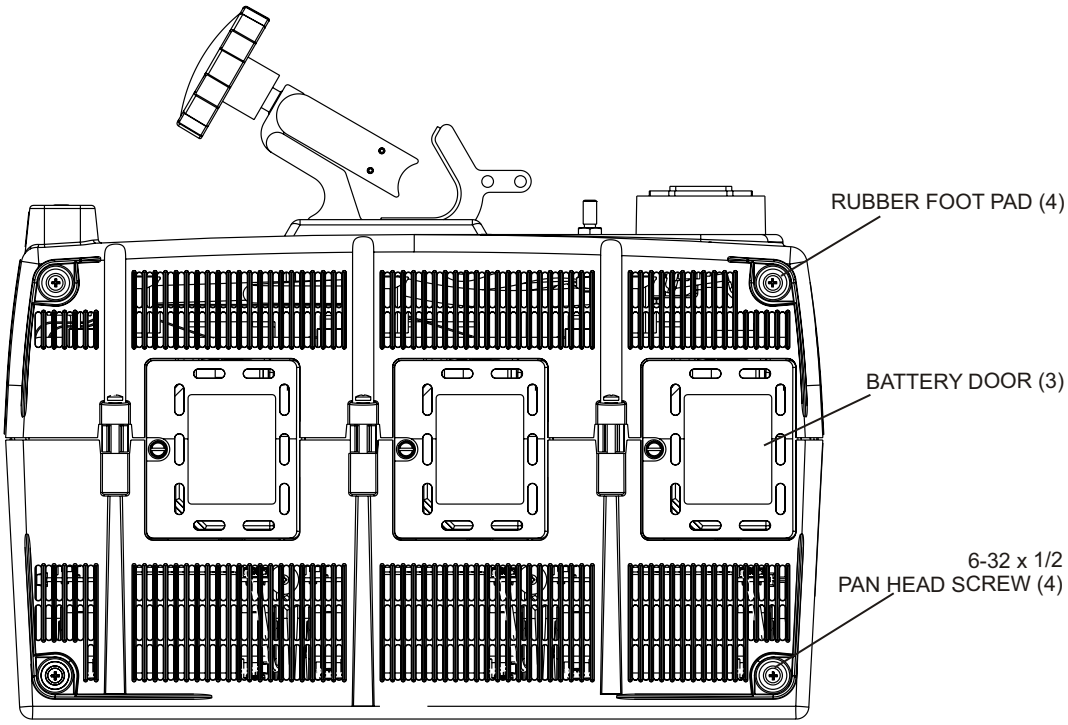



**Figure 7-1. Bottom View**

## 7.2.4
# BATTERY, WIRE HARNESS, DOOR, AND DOOR PAD REPLACEMENT

Recommended tools for this procedure are:

- Medium size flat blade screwdriver
- Long needle nose pliers
- X-acto knife
- Battery cable connector tool (P/N 519-89318-001), or equivalent
- Mild solvent
- Lint-free cloth

Replacement parts for this procedure are:

**Assembly, Battery, with Wire Harness**
**Door, Battery**
**Pad, Door**
**Ring, Retaining**
**Screw, 6-32 x 1/2, Hex Head, Slotted, with Washer**

To replace a battery, wire harness, door, or door pad see *Figure 7-2*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Place the infuser face down on a soft flat surface.
3. Using the flat blade screwdriver, remove the screw and retaining ring that attach the battery door to the infuser, and remove the door.
4. Inspect the battery door and replace, if required.
5. If the battery door pad is defective, remove it and clean the door with mild solvent. Dry the battery door thoroughly, and install the replacement pad on the door.
6. Disconnect the battery harness from the charger circuit cable. Carefully pull the battery harness wires and connector outside the enclosure, and remove the battery.
7. Using the needle nose pliers, remove the wire harness connectors from the battery terminals.
8. Using the battery cable connector tool, install the wire harness connectors onto the terminals of the replacement battery. Confirm the red wire is installed on the positive **(+)** terminal next to the red marker on top of the battery, and the black wire is installed on the negative **(-)** terminal.

   **CAUTION: Do not allow the terminals to come into contact with each other.**

9. Connect the replacement battery harness to the charger circuit cable, and insert the replacement battery into the enclosure. The cable connectors are keyed so that cables cannot be connected incorrectly.

   **Note:** Confirm the battery harness is not pinched between the battery and the enclosure.

10. Replace the battery door using the screw and retaining ring that were removed in step 3.
11. Press **[ON/OFF]** with the infuser disconnected from AC power, and verify the front panel battery symbol illuminates.
12. Access the **BIOMED SETTINGS** screen and press **[CHANGE BATTERY]**.

    **Note:** The **[CHANGE BATTERY]** softkey will not appear on earlier versions of the Plum A+3.

Replacement of the battery door and door pad is routine maintenance and no verification procedure is normally required. However, if the infuser may have been damaged during the procedure, perform the PVT in *Section 5.2*.

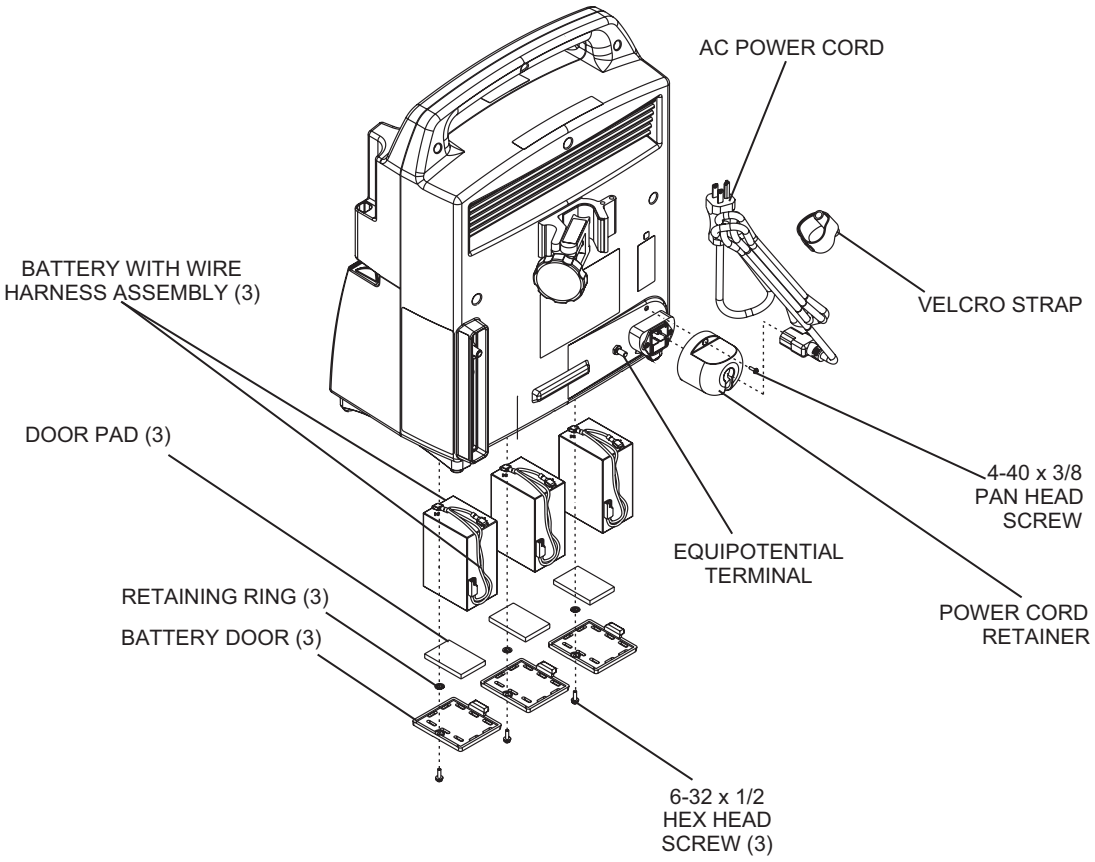



**Figure 7-2. AC Power Cord Assembly and Battery Assembly**

## 7.2.5
# AC POWER CORD, RETAINER, AND VELCRO STRAP REPLACEMENT

The recommended tool for this procedure is a #2 Phillips screwdriver.

Replacement parts for this procedure are:

**Cordset, AC Power, Hospital Grade, Detachable**
**Retainer, AC Power Cord**
**Strap, Velcro, AC Power Cord**
**Screw, 4-40 x 3/8, Pan Head, Phillips**

To replace the AC power cord, retainer, or Velcro strap see *Figure 7-2*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.
3. Using the Phillips screwdriver, remove the screw from the AC power cord retainer. Turn the power cord retainer approximately 1/8 turn counterclockwise.
4. Unplug the power cord, and slide the plug through the retainer.

   **Note:** Remove the AC power cord from its receptacle by grasping the plug. Do not pull the cord.
5. Remove the Velcro strap from the power cord. Inspect the Velcro strap for wear and replace, if required. Attach the strap to the replacement power cord.
6. Inspect the retainer and replace, if required.
7. Install the replacement AC power cord in the exact reverse order of removal.
8. Reinstall the batteries and connect the infuser to AC power.
9. Press **[ON/OFF]** and verify the infuser powers on.

Replacement of the AC power cord, retainer, and Velcro strap is routine maintenance and no verification procedure is normally required. However, if the infuser may have been damaged during the procedure, perform the PVT in *Section 5.2*.

## 7.2.6
# SEPARATING THE FRONT ENCLOSURE, REAR ENCLOSURE, AND MAIN CHASSIS ASSEMBLY

The front enclosure consists of an upper assembly and a lower assembly. The main chassis assembly consists of an upper chassis and a lower chassis.

The recommended tool for this procedure is a #2 Phillips screwdriver.

Replacement parts for this procedure are:

**Enclosure, Upper Front**
**Enclosure, Lower Front**
**Enclosure, Rear**
**Chassis, Upper**
**Chassis, Lower**
**Screw, 6-32 x 1/2, Pan Head, Phillips**
**Screw, 6-32 x 1 1/4, Pan Head, Phillips**
**Screw, 6-32 x 2 3/4, Pan Head, Phillips**
**Screw, 8-32 x 3 1/2, Pan Head, Phillips**
**Washer, Flat, #6**
**Washer, Flat #8**

To separate the front enclosure, rear enclosure, and main chassis assembly see *Figure 7-3*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.
3. Remove the AC power cord and retainer as described in *Section 7.2.5*.
4. Using the Phillips screwdriver, remove the screws from the rear enclosure.
5. Remove the rear enclosure by lifting it up and to the side.
6. Disconnect the three internal power connectors.
7. Using the Phillips screwdriver, remove the screws from the bottom corners of the center mechanism.
8. Set the infuser upright and remove the upper front enclosure by pulling it away from the upper chassis.
9. Remove the lower front enclosure by tilting the infuser back approximately 10 degrees, and pull the lower front enclosure away from the lower chassis.
10. Reassemble the front enclosure, rear enclosure, and main chassis assembly in the exact reverse order of disassembly. Follow the screw placement sequence as illustrated in *Figure 7-4*.

    **Note:** When reassembling the upper front enclosure, lift all three door handles first.

To verify successful assembly, perform the PVT in *Section 5.2*.

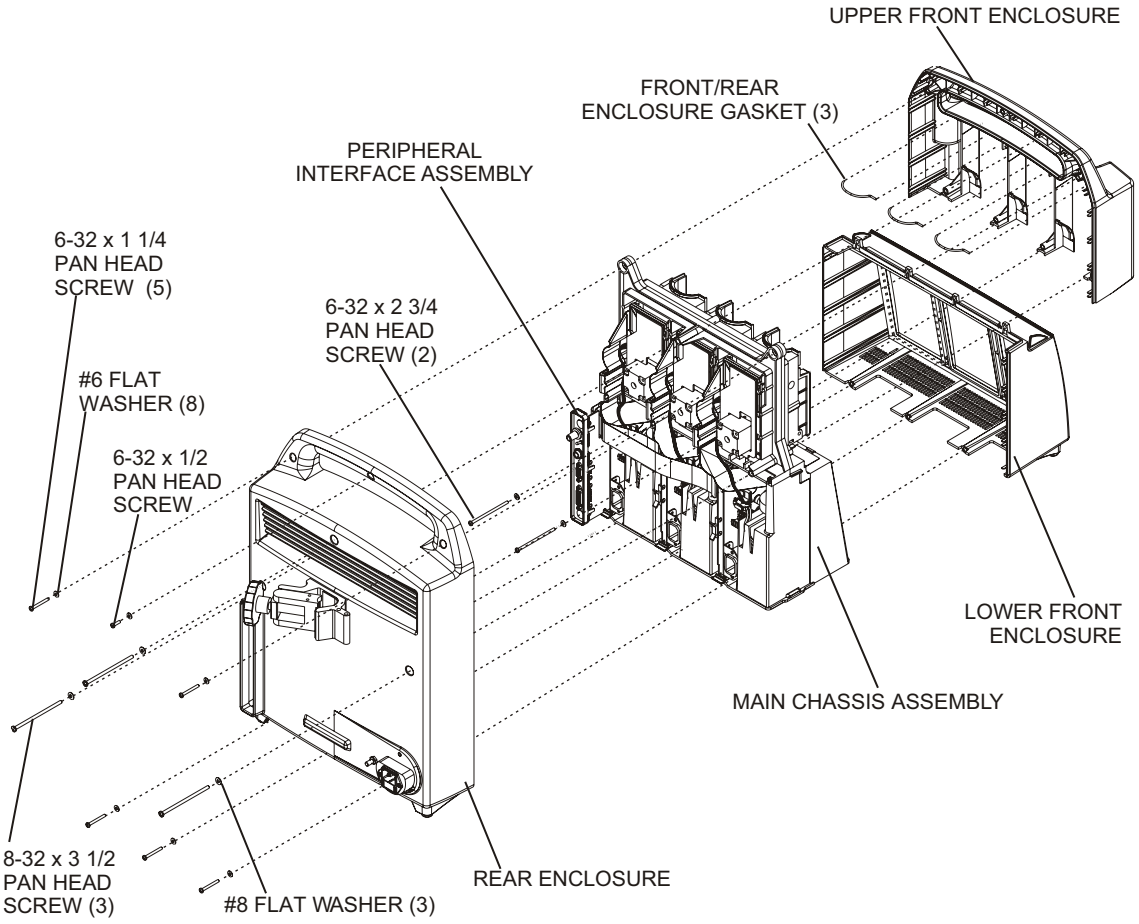



**Figure 7-3. Front Enclosures, Rear Enclosure, and Main Chassis**

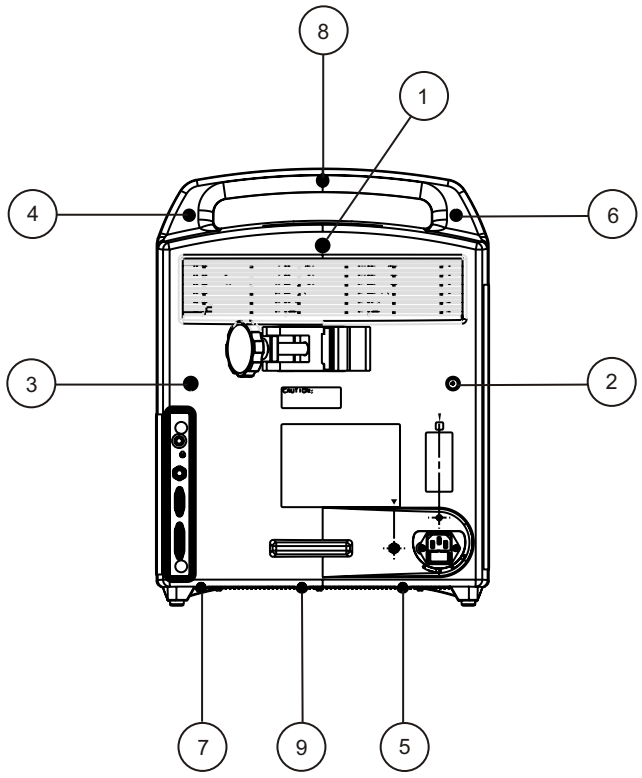



**Figure 7-4. Screw Placement Sequence**

## 7.2.7
# PERIPHERAL INTERFACE ASSEMBLY REPLACEMENT

**CAUTION: Peripheral interface assembly replacement should only be performed after receiving approval from Hospira.**

Replacement parts for this procedure are:

**Assembly, Peripheral Interface**
**Assembly, Cable, Peripheral #1**
**Assembly, Cable, Peripheral #2**

To replace the peripheral interface assembly proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.
3. Remove the rear enclosure as described in *Section 7.2.6*.
4. Disconnect peripheral cable #1 from the peripheral interface PWA.
5. Disconnect peripheral cable #2 from the peripheral interface PWA.
6. Depress the retention clip and carefully pull the peripheral interface assembly away from the infuser.

   **Note:** When removing the peripheral interface assembly, note the placement guides where the peripheral interface PWA rests.

7. Install the replacement peripheral interface assembly in the exact reverse order of removal.

   **Note:** Verify the peripheral interface PWA is placed properly between the guides and fits correctly into the CPU PWA.

8. Reinstall the batteries and connect the infuser to AC power.
9. Turn on the infuser, and verify completion of the self test.

To verify successful peripheral interface assembly replacement, perform the PVT in *Section 5.2*.

## 7.2.8
# PERIPHERAL PWA REPLACEMENT

The recommended tool for this procedure is a #2 Phillips screwdriver.

The replacement part for this procedure is:

**PWA, Peripheral**

**Note:** Replacing the peripheral interface assembly does not change the existing Biomed settings.

To replace a peripheral PWA see *Figure 7-5*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.
3. Remove the rear enclosure as described in *Section 7.2.6*.
4. To replace peripheral PWA #1, disconnect peripheral cable #1, depress the retention clip, and carefully pull the peripheral PWA away from the infuser. Note the location of the cable ties and mounts.
5. To replace peripheral PWA #2, disconnect peripheral cable #2, depress the retention clip, and carefully pull the peripheral PWA away from the infuser. Note the location of the cable ties and mounts.
6. Replace peripheral PWA #1 and peripheral PWA #2 in the exact reverse order of removal.

   **Note:** Verify the peripheral PWAs are placed properly between the guides and fit correctly.

7. Reinstall the batteries and connect the infuser to AC power.

To verify successful peripheral PWA replacement, perform the PVT in *Section 5.2*.

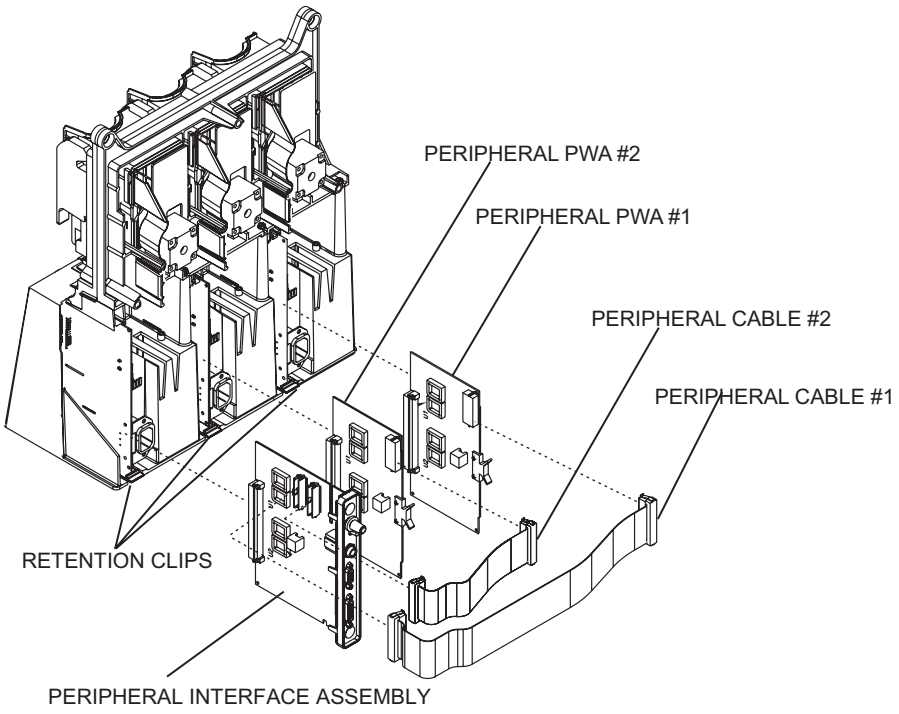



**Figure 7-5. Peripheral Interface Assembly and Peripheral PWAs**

## 7.2.9
# PERIPHERAL COMPONENT REPLACEMENT

Peripheral component replacement includes the replacement of the volume control knob and the peripheral cover.

To replace peripheral components see *Figure 7-6*, then proceed as detailed in the following sections.

7.2.9.1
## VOLUME CONTROL KNOB REPLACEMENT

Recommended tools for this procedure are a medium size flat blade screwdriver, an X-acto knife, and long needle nose pliers.

Replacement parts for this procedure are:

**Assembly, Volume Control Knob**
**Cap, Knob**
**Cover, Knob**

To replace the volume control knob see *Figure 7-6*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.
3. Remove the peripheral interface assembly as described in *Section 7.2.7*.
4. Using the X-acto knife, lift the volume control knob end cap away from the knob, exposing a flat head screw.
5. Using the flat blade screwdriver, remove the screw that secures the knob.
6. Using long needle nose pliers, remove the knob cap, knob cover, and volume control knob.
7. Install the replacement volume control knob in the exact reverse order of removal.
8. Install the peripheral interface assembly in the exact reverse order of removal.
9. Reinstall the batteries and connect the infuser to AC power.

Replacement of the volume control knob is routine maintenance and no verification procedure is normally required. However, if the infuser may have been damaged during the procedure, perform the PVT in *Section 5.2*.

7.2.9.2
## PERIPHERAL COVER REPLACEMENT

Recommended tools for this procedure are a #2 Phillips screwdriver, set of nutdrivers, an X-acto knife, custom nutdriver, and long needle nose pliers.

Replacement parts for this procedure are:

**Cover, Peripheral**
**Shield, Spring, ESD**
**Seal, Rectangle**
**Seal, Round**
**Screw, 4-40 x 3/8, Hex Head, Nylon**
**Screw, 4-40 x 3/8, Pan Head, Phillips, with Washer**
**Nut, Hex, Nurse Call Jack**
**Nut, Hex, 4-40**
**Washer, Flat, #4, Nylon**

To replace the peripheral cover see *Figure 7-6*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.

3. Remove the peripheral interface assembly as described in *Section 7.2.7*.
4. Remove the volume control knob as described in *Section 7.2.9.1*.
5. Using a 5/16 nutdriver, remove the nut that secures the potentiometer to the peripheral cover. Using the needle nose pliers, remove the lock washer.
6. Using the custom nutdriver, remove the hex nut that secures the nurse call jack to the peripheral cover.
7. Inspect the rectangle seal and round seals and replace, if required.
8. Using the Phillips screwdriver, remove the screws that secure the peripheral interface PWA to the cover.

   **Note:** Note the position of the two hex nuts installed in the PWA mounting brackets located on the peripheral cover. Retain the nuts for re-assembly.

9. Using a 3/16 nutdriver, remove the screws from the DataPort connector.
10. Inspect the ESD spring and replace, if required.
11. Install the replacement peripheral cover in the exact reverse order of removal.
12. Install the volume control knob and nurse call jack nut in the exact reverse order of removal.
13. Install the peripheral interface assembly as described in *Section 7.2.7*.
14. Reinstall the batteries, and connect the device to AC power.
15. Turn on the infuser, and verify completion of the self test.

To verify successful peripheral cover replacement, perform the PVT in *Section 5.2*.

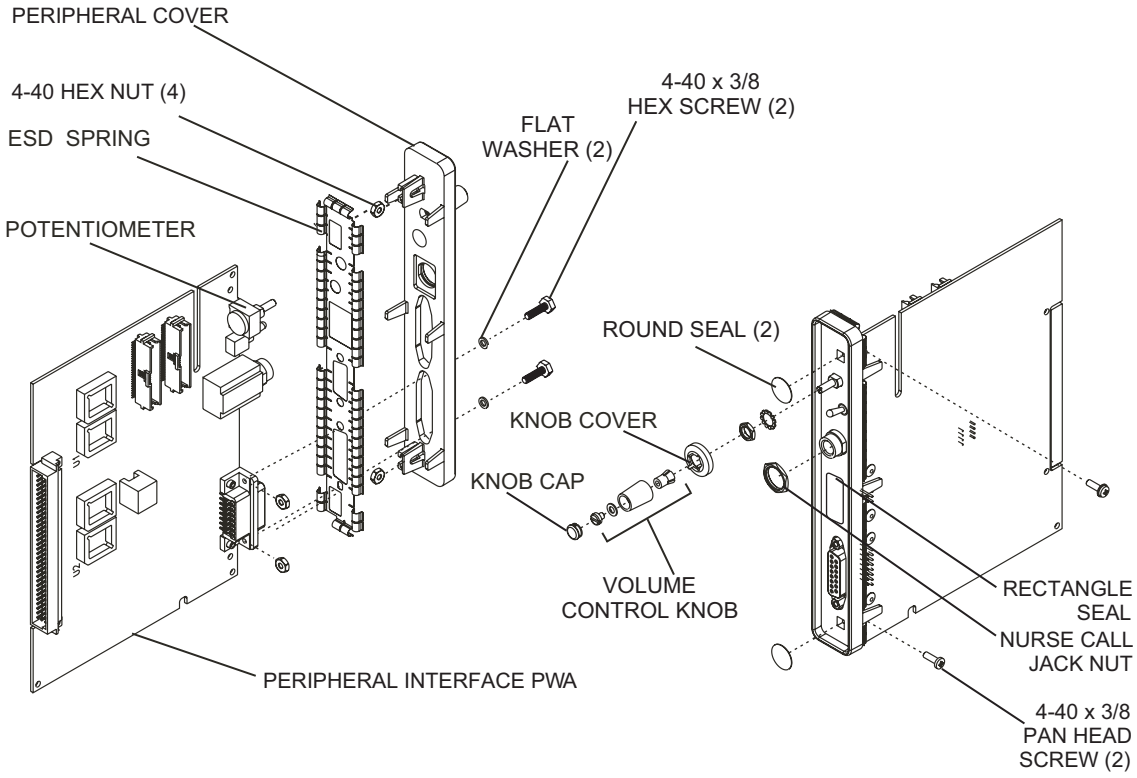



**Figure 7-6. Peripheral Interface Assembly Components**

## 7.2.10
# FRONT/REAR ENCLOSURE GASKET REPLACEMENT

The recommended tool for this procedure is needle nose pliers.

The replacement part for this procedure is:

**Gasket, Front/Rear Enclosure**

**Note:** Clean and remove any foreign matter on the replacement gasket or in the spaces where the replacement gasket is to be installed.

To replace a front/rear enclosure gasket see *Figure 7-3*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.
3. Separate the front enclosure, rear enclosure, and main chassis assembly as described in *Section 7.2.6*.
4. Using the needle nose pliers, remove the front/rear enclosure gasket from the upper front enclosure *(see Figure 7-3)*.
5. Install the replacement front/rear gasket in the exact reverse order of removal.
6. Join the front enclosure, rear enclosure, and main chassis assembly in the exact reverse order of separation.
7. Reinstall the batteries and connect the infuser to AC power.

To verify successful front/rear enclosure gasket replacement, perform the PVT in *Section 5.2*.

## 7.2.11
# LOWER FRONT ENCLOSURE GASKET REPLACEMENT

Lower front enclosure gasket replacement includes the replacement of the following:

- EMI D-shape gaskets
- Keypad gaskets
- Top seal gaskets

To replace the lower front enclosure gaskets see *Figure 7-7*, then proceed as detailed in the following sections.

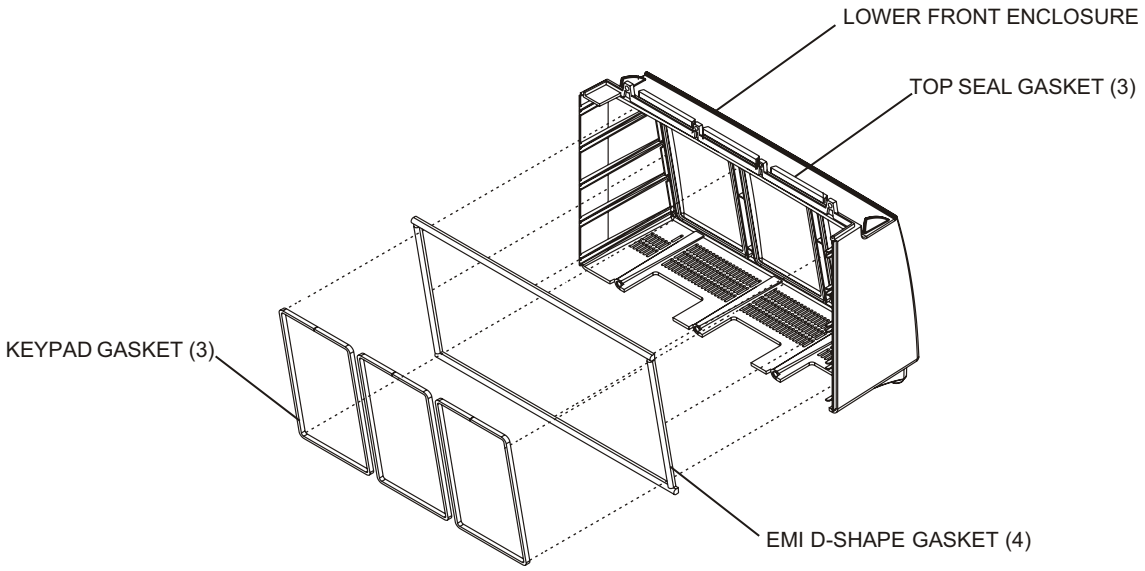



**Figure 7-7. Lower Front Enclosure Gaskets**

7.2.11.1
## EMI GASKET REPLACEMENT

The recommended tool for this procedure is needle nose pliers.

The replacement part for this procedure is:

**Gasket, EMI, D-Shape, 6.62 in.**
**Gasket, EMI, D-Shape, 13 in.**

To replace an EMI gasket see *Figure 7-7*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.
3. Separate the front enclosure, rear enclosure, and main chassis assembly as described in *Section 7.2.6*.
4. Using the needle nose pliers, remove the EMI d-shape gasket.

   **Note:** Clean and remove any foreign matter on the replacement gasket or in the space where the replacement gasket is to be installed.

5. Remove the backing from the replacement EMI gasket to expose the adhesive and press the gasket into place on the lower front enclosure.
6. Join the front enclosure, rear enclosure, and main chassis assembly in the exact reverse order of separation.
7. Reinstall the batteries and connect the infuser to AC power.

To verify successful EMI gasket replacement, perform the PVT in *Section 5.2*.

7.2.11.2
## KEYPAD GASKET REPLACEMENT

The recommended tool for this procedure is needle nose pliers.

The replacement part for this procedure is:

**Gasket, Keypad**

To replace a keypad gasket see *Figure 7-7*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.
3. Separate the front enclosure, rear enclosure, and main chassis assembly as described in *Section 7.2.6*.
4. Using the needle nose pliers, remove the keypad gasket.

   **Note:** Clean and remove any foreign matter on the replacement gasket or in the space where the replacement gasket is to be installed.
5. Install the replacement keypad gasket in the gasket grooves. The gasket gap created by the ends of the gasket must be placed at the top of the keypad window.
6. Join the front enclosure, rear enclosure, and main chassis assembly in the exact reverse order of separation.
7. Reinstall the batteries and connect the infuser to AC power.

To verify successful keypad gasket replacement, perform the PVT in *Section 5.2*.

7.2.11.3
## TOP SEAL GASKET REPLACEMENT

The recommended tool for this procedure is an X-acto knife.

The replacement part for this procedure is:

**Gasket, Top Seal**

To replace a top seal gasket see *Figure 7-7*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Separate the front enclosure, rear enclosure, and main chassis assembly as described in *Section 7.2.6*.
3. Using the X-acto knife, remove the top seal gasket.
4. Using a light solvent, clean the area of all foreign matter.
5. Remove the backing from the replacement top seal gasket to expose the adhesive and press the gasket into place on the lower front enclosure.
6. Join the front enclosure, rear enclosure, and main chassis assembly in the exact reverse order of separation.
7. Reinstall the batteries and connect the infuser to AC power.

To verify successful top seal gasket replacement, perform the PVT in *Section 5.2*.

## 7.2.12
# REAR ENCLOSURE ASSEMBLY COMPONENT REPLACEMENT

Rear enclosure assembly component replacement includes replacement of the following:

- Rear enclosure gaskets
- Pole clamp assembly, backing plate, and insulator
- Equipotential terminal
- Internal AC power cord
- AC connector
- Fuses

To replace the rear enclosure assembly components see *Figure 7-8* and *Figure 7-9*, then proceed as detailed in the following sections.

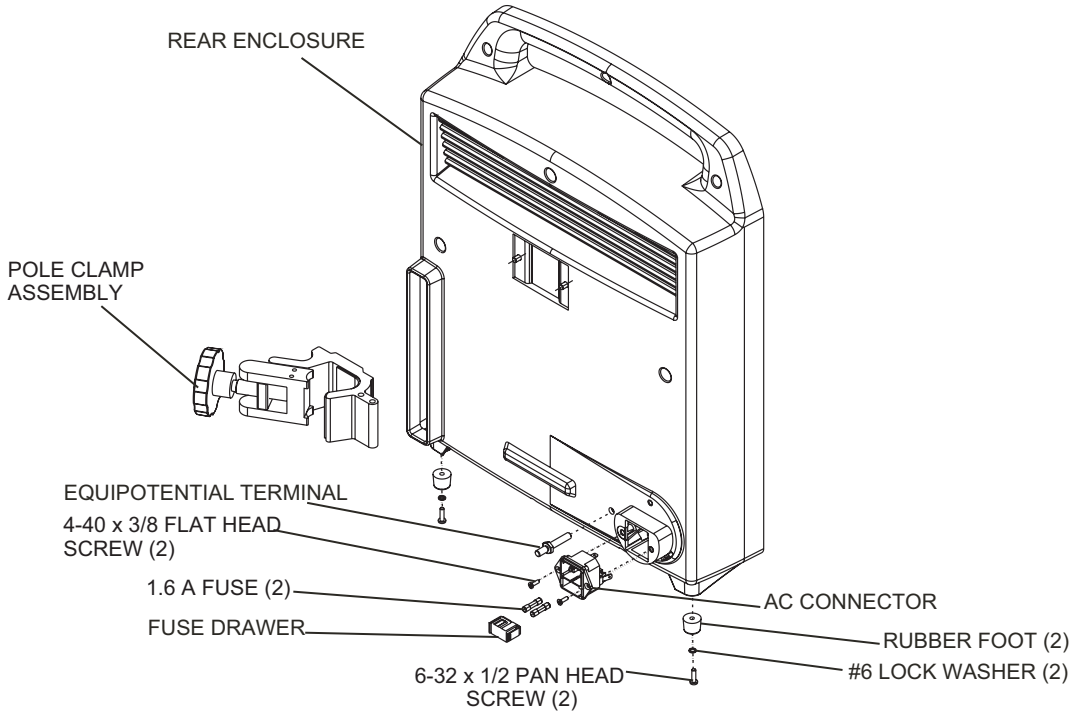



**Figure 7-8. External Rear Enclosure Assembly Components**

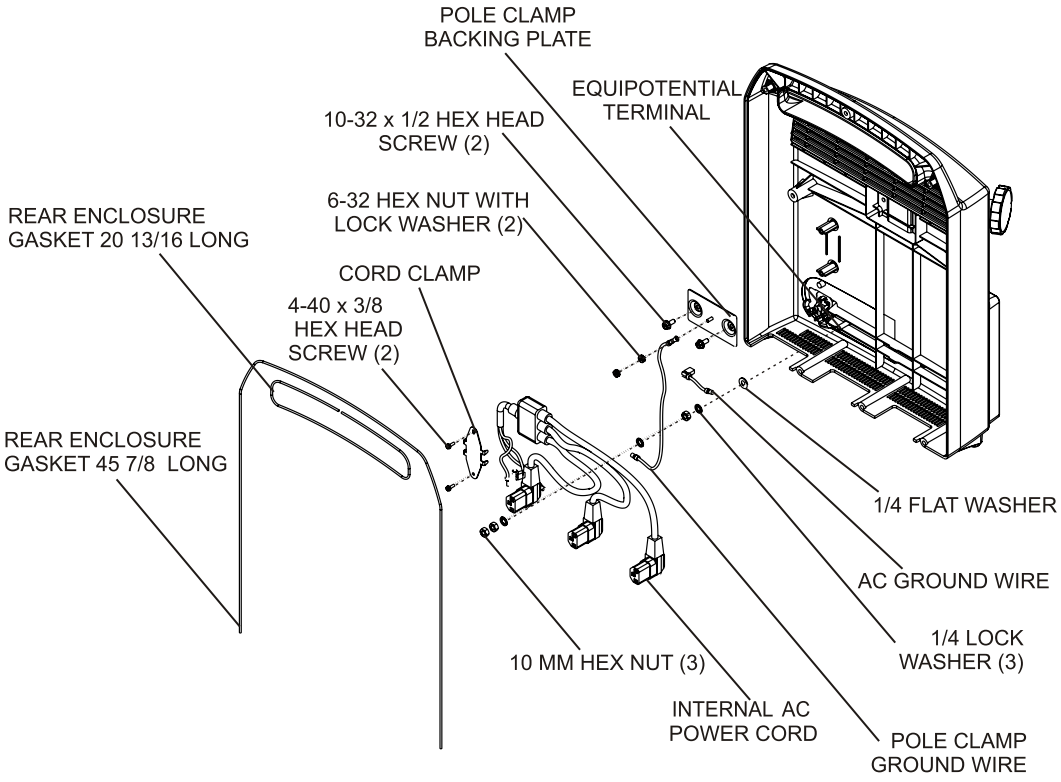



**Figure 7-9. Internal Rear Enclosure Assembly Components**

7.2.12.1

# POLE CLAMP ASSEMBLY AND BACKING PLATE REPLACEMENT

Recommended tools for this procedure are a set of nutdrivers and a medium size flat blade screwdriver.

Replacement parts for this procedure are:

**Assembly, Pole Clamp**
**Plate, Backing, Pole Clamp**
**Tape, Insulation**
**Wire, Ground, Pole Clamp**
**Terminal, Equipotential**
**Screw, 10-32 x 1/2, Hex Head, Slotted**
**Nut, Hex, 6-32**
**Nut, Hex, 10 mm**

To replace the pole clamp assembly and backing plate see *Figure 7-8* and *Figure 7-9*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.
3. Separate the front enclosure and rear enclosure as described in *Section 7.2.6*.
4. Using a 5/16 nutdriver, remove the nuts that secure the ground wire to the backing plate.
5. Using a 10 mm nutdriver, remove the nuts and washers that secure the ground wire to the equipotential terminal.
6. Inspect the ground wire and equipotential terminal and replace, if required.
7. Using the flat blade screwdriver, remove the screws that secure the pole clamp assembly and backing plate, and remove the pole clamp and backing plate from the rear enclosure.
8. Install the replacement pole clamp assembly and backing plate, using the screws that were removed in step 7.
9. Completely cover the pole clamp backing plate with insulation tape. Press firmly to adhere the insulation tape to the backing plate.

   **CAUTION: Assure the insulation tape covers the entire backing plate. If the backing plate is exposed, the power supply PWA may be damaged when power is applied to the infuser.**

10. Secure the ground wire to the backing plate and equipotential terminal.
11. Join the front enclosure and rear enclosure in the exact reverse order of separation.
12. Reinstall the batteries and connect the infuser to AC power.

To verify successful pole clamp assembly and backing plate replacement, perform the PVT in *Section 5.2*.

7.2.12.2
## INTERNAL AC POWER CORD REPLACEMENT

Recommended tools for this procedure are a medium size flat blade screwdriver, needle nose pliers, and a set of nutdrivers.

Replacement parts for this procedure are:

**Cord, Internal, AC Power**
**Clamp, Internal Power Cord**
**Wire, Ground, AC Power**
**Screw, 4-40 x 3/8, Hex Head, Slotted**
**Washer, Flat, 1/4**
**Washer, Lock, 1/4**

To replace the internal AC power cord see *Figure 7-9*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.
3. Separate the front and rear enclosures as described in *Section 7.2.6*.
4. Using the flat blade screwdriver, remove the screws from the internal power cord clamp.
5. Using the needle nose pliers, remove the wires from the AC connector.
6. Using a 10 mm nutdriver, remove the hex nuts and washers that secure the AC ground wire to the equipotential terminal.
7. Inspect the ground wire and replace, if required.
8. Install the replacement internal AC power cord in the exact reverse order of removal.
9. Join the front enclosure and rear enclosure in the exact reverse order of separation.
10. Reinstall the batteries and connect the infuser to AC power.

To verify successful internal AC power cord replacement, perform the PVT in *Section 5.2*.

7.2.12.3
## AC CONNECTOR REPLACEMENT

Recommended tools for this procedure are needle nose pliers and a #2 Phillips screwdriver.

Replacement parts for this procedure are:

**Connector, AC**
**Screw, 4-40 x 3/8, Flat Head, Phillips**

To replace the AC connector see *Figure 7-8*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.
3. Separate the rear enclosure and main chassis assembly as described in *Section 7.2.6*.
4. Remove the AC power cord retainer and AC power cord as described in *Section 7.2.5*.

5. Using the needle nose pliers, remove the internal power cord wires and the AC ground wire from the AC connector.
6. Using the Phillips screwdriver, remove the screws that secure the AC connector to the rear enclosure.
7. Install the replacement AC connector in the exact reverse order of removal.
8. Join the rear enclosure and main chassis assembly in the exact reverse order of separation.
9. Reinstall the batteries and connect the infuser to AC power.

To verify successful AC connector replacement, perform the PVT in *Section 5.2*.

### 7.2.12.4
## FUSE REPLACEMENT

Recommended tools for this procedure are a #2 Phillips screwdriver and a small flat blade screwdriver.

Replacement parts for this procedure are:

**Fuse, 1.6 A, 250 V**
**Drawer, Fuse**

To replace the fuses see *Figure 7-8*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.
3. Separate the rear enclosure and main chassis assembly as described in *Section 7.2.6*.
4. Remove the power cord retainer and power cord as described in *Section 7.2.5*.
5. Locate the fuse drawer directly below the AC power receptacle. Insert the flat blade screwdriver between the right locking tab of the fuse drawer and the AC connector housing. Press the tab toward the center of the fuse drawer to release it. Verify the fuse drawer moves slightly outward.
6. Repeat step 5 to release the left locking tab. Grasp both locking tabs and remove the fuse drawer from the AC connector.
7. Inspect the fuse drawer and replace, if required.

   **CAUTION: Confirm the replacement fuse rating is identical to the rating indicated on the fuse drawer.**

8. Remove the fuses and replace with approved fuses only *(see Section 8)*. Do not use any other fuse types.
9. Insert the fuse drawer into the receptacle, then press the fuse drawer into the AC connector until it clicks into position.
10. Reinstall the power cord retainer and power cord in the exact reverse order of disassembly.
11. Reinstall the batteries and connect the infuser to AC power.

To verify successful fuse replacement, perform the PVT in *Section 5.2*.

### 7.2.12.5
## REAR ENCLOSURE GASKET REPLACEMENT

The recommended tool for this procedure is needle nose pliers.

Replacement parts for this procedure are:

**Gasket, Rear Enclosure, 20 13/16**
**Gasket, Rear Enclosure, 45 7/8**

To replace a rear enclosure gasket see *Figure 7-9*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.
3. Separate the rear enclosure and main chassis assembly as described in *Section 7.2.6*.
4. Using the needle nose pliers, remove the rear enclosure gasket.

   **Note:** Clean and remove any foreign matter on the replacement gasket or in the space where the replacement gasket is to be installed.
5. Install the replacement rear enclosure gasket by pressing it into the gasket channel.
6. Join the front enclosure and rear enclosure in the exact reverse order of separation.
7. Reinstall the batteries and connect the infuser to AC power.

To verify successful rear enclosure gasket replacement, perform the PVT in *Section 5.2*.

### 7.2.13
## MINIPOLE ASSEMBLY REPLACEMENT

The minipole assembly is an accessory that attaches to the infuser through two holes in the pole clamp extrusion and is held in place by a cotter ring. The cotter ring passes through a hole near the end of the longer of the two vertical rods on the bag hanger, and prevents the removal of the minipole from the holes in the pole clamp.

The recommended tool for this procedure is needle nose pliers.

Replacement parts for this procedure are:

**Assembly, Minipole**
**Ring, Cotter**

To replace the minipole assembly see *Figure 7-13*, then proceed as follows:

1. Turn off the infuser and disconnect the device from AC power.
2. Place the infuser face down on a soft surface.
3. Grasp the cotter ring and twist, rotate, and remove the cotter ring from the rod hole.
4. Remove the bag hanger from the pole clamp rod holes, and remove the minipole.
5. Install the replacement minipole assembly in the exact reverse order of removal.

Replacement of the minipole assembly is routine maintenance and no verification procedure is normally required. However, if the infuser may have been damaged during the procedure perform the PVT as described in *Section 5.2*.

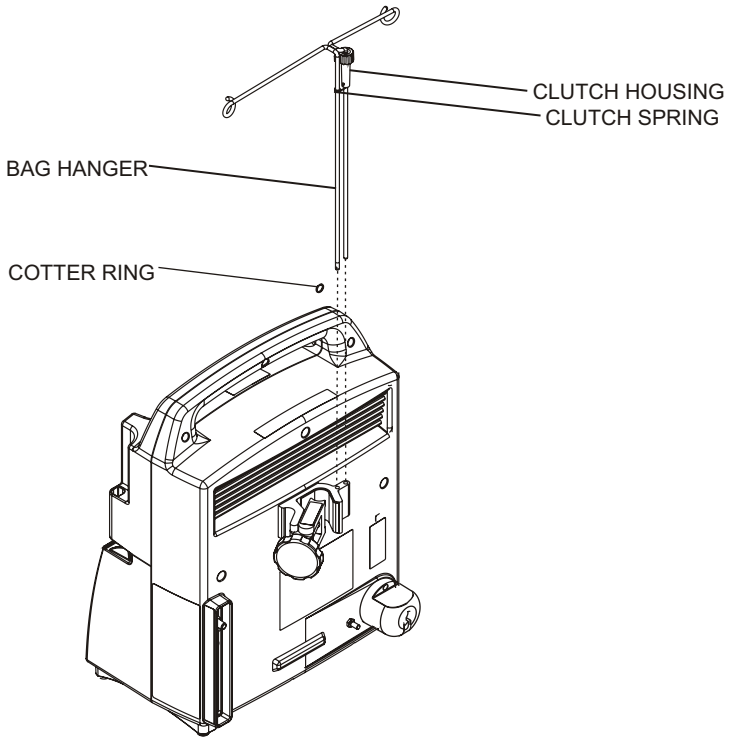



**Figure 7-10. Minipole Assembly**

## 7.2.14
# MAIN CHASSIS ASSEMBLY COMPONENT REPLACEMENT

Main chassis assembly component replacement includes replacement of the following:

- Power supply PWA
- Keypad
- Display
- CPU PWA
- Piezo alarm
- Mechanism assembly
- Cassette door
- Fluid shield
- Opener handle

To replace the main chassis assembly components see *Figure 7-11*, then proceed as detailed in the following sections.

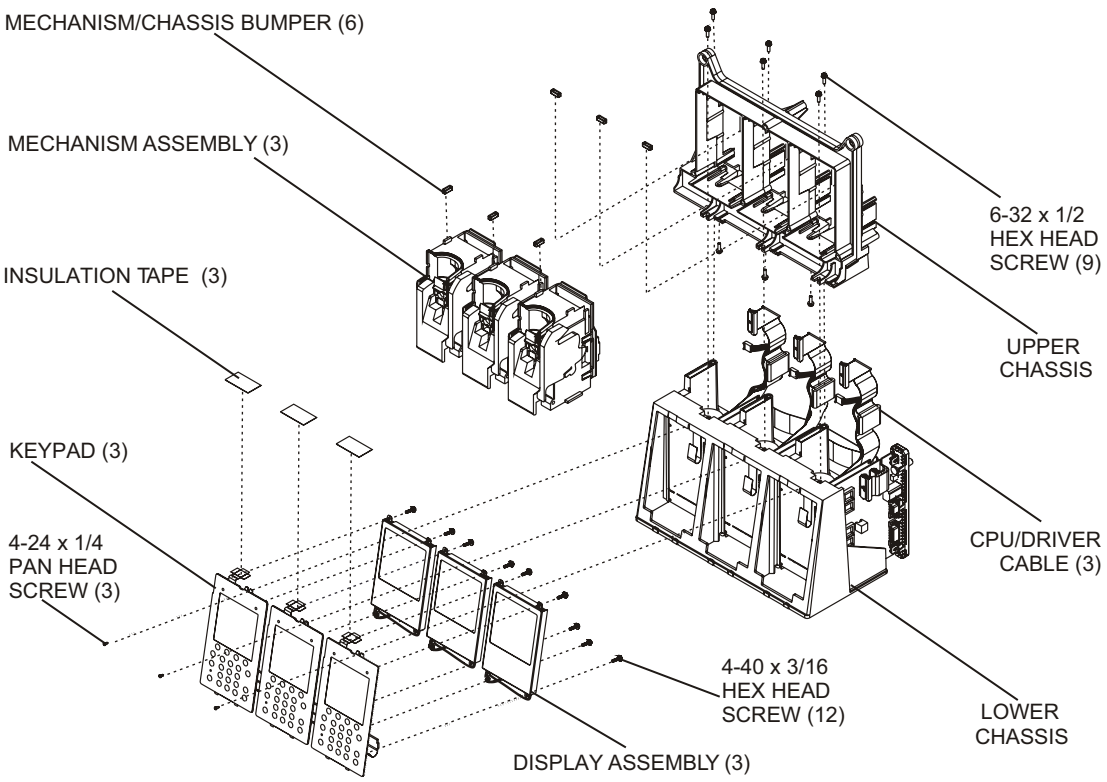



**Figure 7-11. Main Chassis Assembly Components (1 of 2)**

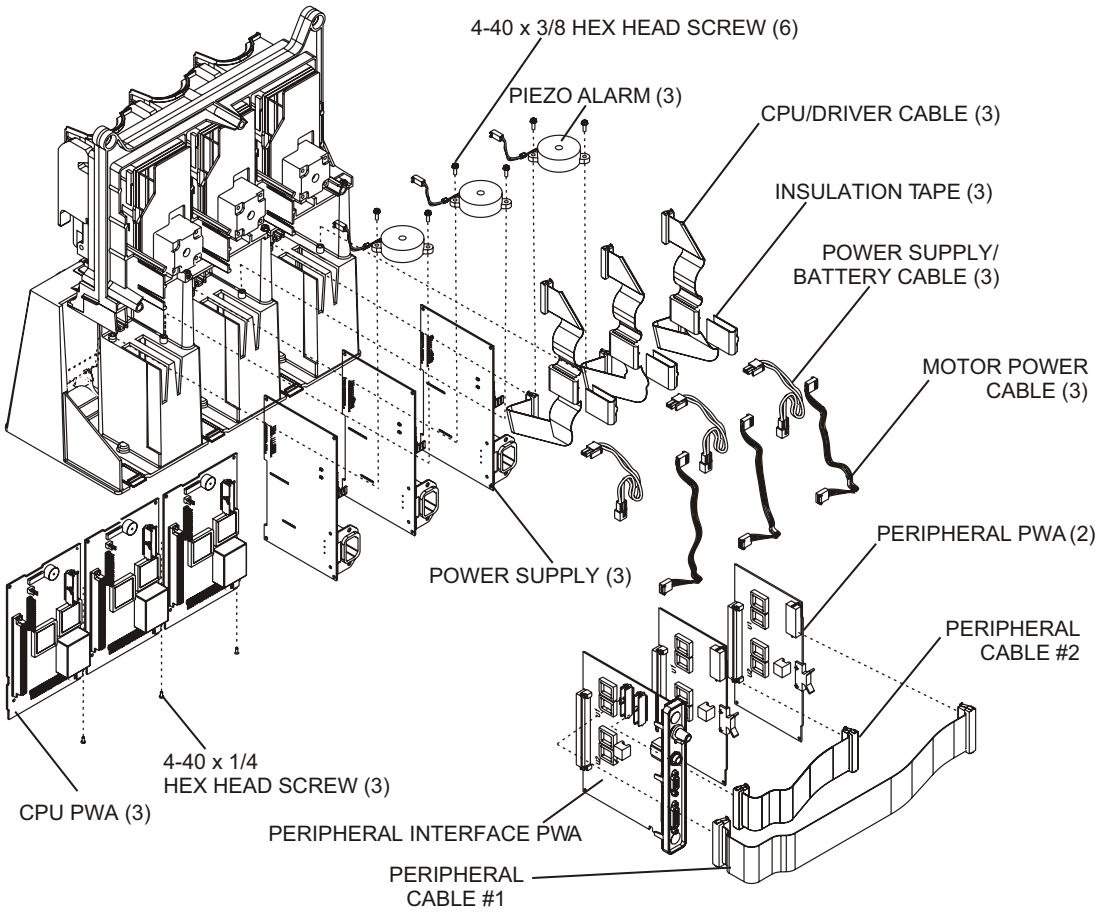



**Figure 7-11. Main Chassis Assembly Components (2 of 2)**

### 7.2.14.1
## POWER SUPPLY PWA REPLACEMENT

The recommended tool for this procedure is a medium size flat blade screwdriver.

Replacement parts for this procedure are:

**PWA, Power Supply**
**Assembly, Cable, Power Supply/Battery**

To replace a power supply PWA see *Figure 7-11 (2 of 2)*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.
3. Separate the rear enclosure from the main chassis as described in *Section 7.2.6*.
4. Disconnect the battery cable from the power supply PWA.
5. Disconnect the peripheral cables from the peripheral PWAs.
6. Remove the power supply PWA by pressing down on the finger tab at the bottom front of the power supply PWA. Slide the power supply PWA away from the CPU PWA.
7. Install the replacement power supply PWA in the exact reverse order of removal.

   **Note:** Verify the replacement power supply PWA connects to the CPU PWA correctly to avoid misalignment.

   **Note:** If an alarm sounds, press **[ON/OFF]** to deactivate the alarm.
8. Join the rear enclosure and main chassis assembly in the exact reverse order of separation.
9. Reinstall the batteries and connect the infuser to AC power.

To verify successful power supply PWA replacement, perform the PVT in *Section 5.2*.

### 7.2.14.2
## KEYPAD REPLACEMENT

Recommended tools for this procedure are a #2 Phillips screwdriver, medium size flat blade screwdriver, and an X-acto knife.

Replacement parts for this procedure are:

**Assembly, Keypad**
**Tape, Insulation**
**Screw, 4-24 x 1/4, Pan Head, Phillips**

To replace a keypad see *Figure 7-11 (1 of 2)*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.
3. Separate the front enclosure, rear enclosure, and main chassis assembly as described in *Section 7.2.6*.
4. Disconnect the keypad cable from the CPU PWA.
5. Using the X-acto knife, lift the white insulation tape that secures the grounding tab to the main chassis.

6. Using the Phillips screwdriver, remove the screw that secures the keypad and display to the lower main chassis.
7. Carefully disconnect the flex ribbon cable from the display by pushing the connector locking tabs down.
8. Using the flat blade screwdriver, separate the keypad and display by removing the screws that secure the keypad to the display.
9. Install the replacement keypad in the exact reverse order of removal.
10. Install the keypad and display in the exact reverse order of removal.
11. Join the front enclosure, rear enclosure, and main chassis assembly in the exact reverse order of separation.
12. Reinstall the batteries and connect the infuser to AC power.

To verify successful keypad replacement, perform the PVT in *Section 5.2*.

7.2.14.3
## DISPLAY ASSEMBLY REPLACEMENT

Recommended tools for this procedure are a #2 Phillips screwdriver and a medium size flat blade screwdriver.

Replacement parts for this procedure are:

**Assembly, Display**
**Screw, 4-40 x 3/16, Hex Head, Slotted, with Washer**

To replace a display assembly see *Figure 7-11 (1 of 2)*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.
3. Separate the front enclosure, rear enclosure, and main chassis assembly as described in *Section 7.2.6*.
4. Remove the keypad as described in *Section 7.2.14.2*.
5. Disconnect the display cable from the CPU PWA and remove the display.
6. Install the replacement display in the exact reverse order of removal.
7. Reassemble the keypad and display assembly.
8. Join the front enclosure, rear enclosure, and main chassis assembly in the exact reverse order of separation.
9. Reinstall the batteries and connect the infuser to AC power.

To verify successful display assembly replacement, perform the PVT in *Section 5.2*.

7.2.14.4

# CPU/DRIVER CABLE REPLACEMENT

The recommended tool for this procedure is an X-acto knife.

Replacement parts for this procedure are:

**Assembly, Cable, CPU/Driver**
**Tape, Ferrite**
**Tape, Insulation**

To replace a CPU/driver cable see *Figure 7-11 (1 of 2)*, *Figure 7-12*, and *Figure 7-13*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.
3. Separate the front enclosure, rear enclosure, and main chassis assembly as described in *Section 7.2.6*.
4. Remove the peripheral interface PWA as described in *Section 7.2.7*.
5. Remove the peripheral PWAs as described in *Section 7.2.8*.
6. Remove the power supply PWA as described in *Section 7.2.14.1*.
7. Disconnect the CPU/driver cable from the mechanism assembly.
8. Remove the insulating tape that secures the CPU/driver cable and ferrite to the center tab *(see Figure 7-13)*.
9. Remove both ends of ferrite tape from the center tab. Cut off the adhesive strip on one side of the ferrite tape and pull through the ferrite *(see Figure 7-13)*.
10. Remove the CPU/driver cable from the center tab.
11. Remove the CPU PWA as described in *Section 7.2.14.6*.
12. Disconnect the CPU/driver cable from the CPU PWA.
13. Insert ferrite tape through the ferrite of the replacement CPU/driver cable. Assure the adhesive side is facing away from the cable.
14. Position the ferrite between the two line marks on the cable.
15. Route the cable around the tabs as shown in *Figure 7-12*. Assure the pin 1 stripe of the cable faces the front of the infuser. Ferrite should be on the left side of the center tab and between the cable markings.
16. Remove the backing to expose the adhesive and apply both ends of tape completely to the surface of the center tab *(see Figure 7-13)*.
17. Wrap insulation tape around the ferrite and center tab *(see Figure 7-13)*.
18. Connect the CPU/driver cable to the mechanism assembly.
19. Reassemble the infuser in the exact reverse order of disassembly.
20. Reinstall the batteries and connect the infuser to AC power.

To verify successful CPU/driver cable replacement, perform the PVT in *Section 5.2*.

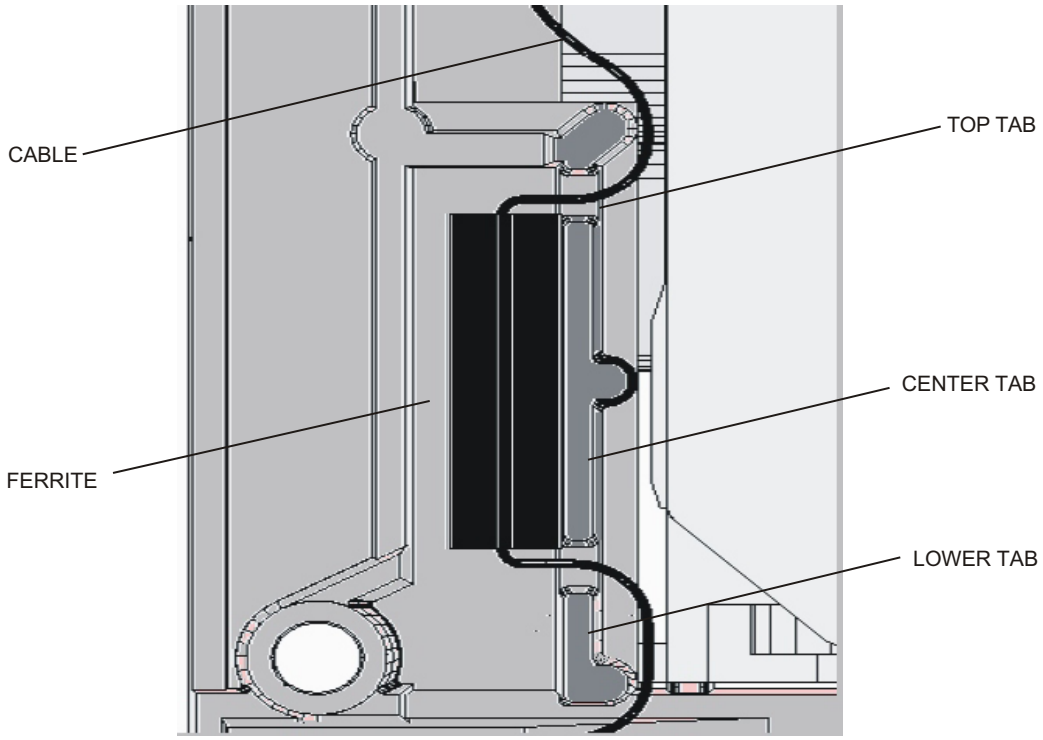



**Figure 7-12. CPU/Driver Cable Routing**

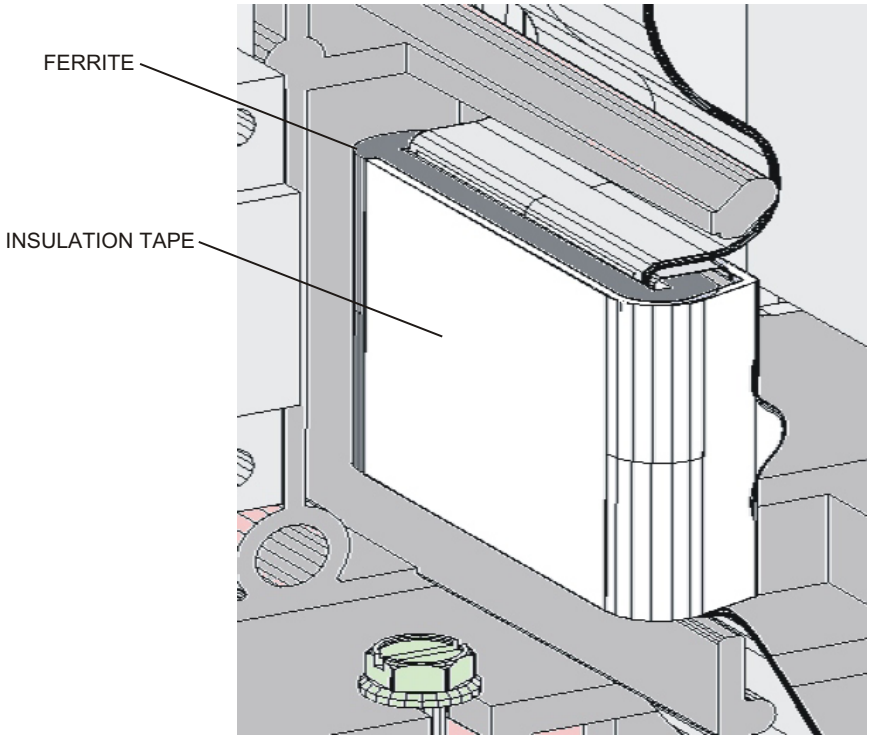



**Figure 7-13. Ferrite Tape Positioning (1 of 2)**

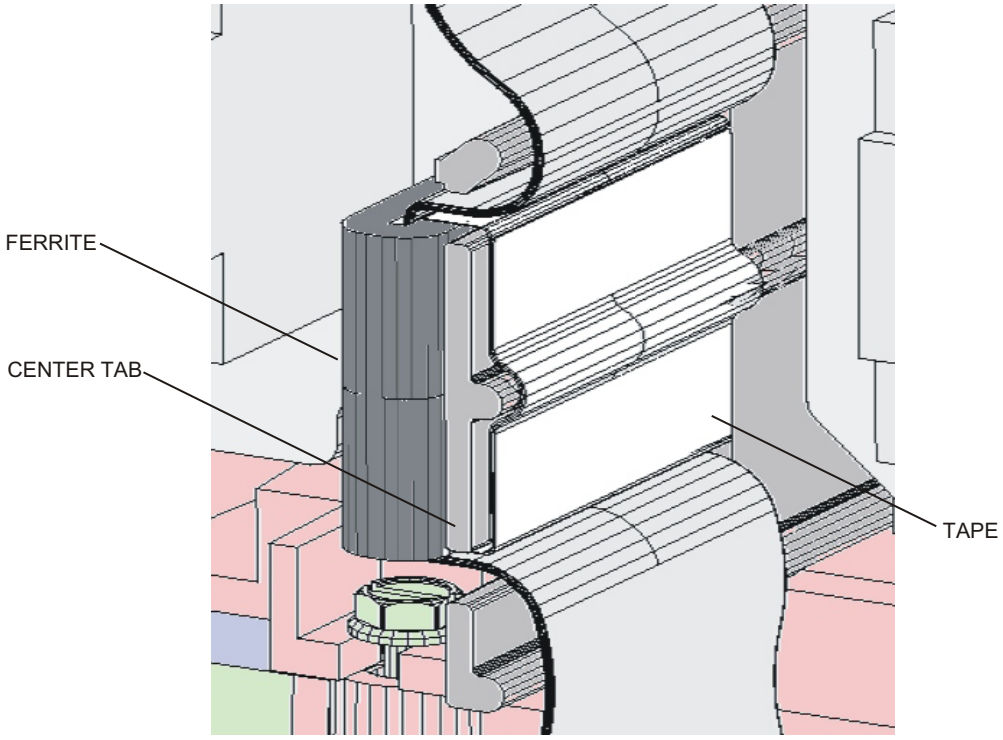



**Figure 7-13. Ferrite Tape Positioning (2 of 2)**

7.2.14.5
## MOTOR POWER CABLE REPLACEMENT

The recommended tool for this procedure is a medium size flat blade screwdriver.

The replacement part for this procedure is:

**Assembly, Cable, Motor Power**

To replace a motor power cable see *Figure 7-11 (2 of 2)*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.
3. Separate the front enclosure, rear enclosure, and main chassis assembly as described in *Section 7.2.6*.
4. Disconnect the motor power cable from the CPU PWA.
5. Remove the mechanism assembly as described in *Section 7.2.14.8*.
6. Disconnect the motor power cable from the mechanism assembly.
7. Install the replacement motor power cable in the exact reverse order of removal.
8. Join the front enclosure, rear enclosure, and main chassis assembly in the exact reverse order of separation.
9. Reinstall the batteries and connect the infuser to AC power.

To verify successful motor power cable replacement, perform the PVT in *Section 5.2*.

7.2.14.6
## CPU PWA REPLACEMENT

Recommended tools for this procedure are a medium size flat blade screwdriver and #2 Phillips screwdriver.

Replacement parts for this procedure are:

**PWA, CPU**
**Screw, 4-40 x 1/4, Hex Head, Slotted, with Washer**

To replace a CPU PWA see *Figure 7-11 (2 of 2)*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.
3. Separate the front enclosure, rear enclosure, and main chassis assembly as described in *Section 7.2.6*.
4. Remove the peripheral interface assembly as described in *Section 7.2.7*.
5. Remove the peripheral PWAs as described in *Section 7.2.8*.
6. Remove the power supply PWA as described in *Section 7.2.14.1*.
7. Disconnect the keypad ribbon cable from the CPU PWA.
8. Disconnect the display cable from the CPU PWA.
9. Disconnect the CPU/driver cable from the mechanism assembly.

10. Disconnect the piezo alarm cable from the CPU PWA.
11. Using the Phillips screwdriver, remove the screw from the bottom of the lower main chassis assembly.
12. Slide the CPU PWA out of the main chassis until J5 on the CPU PWA is accessible.
13. Using the flat blade screwdriver, release the locking tabs that secure the flex cable to the CPU PWA.
14. Install the replacement CPU PWA in the exact reverse order of removal.
15. Join the front enclosure, rear enclosure, and main chassis assembly in the exact reverse order of separation.
16. Reinstall the batteries and connect the infuser to AC power.

To verify successful CPU PWA replacement, perform the PVT in *Section 5.2*.

### 7.2.14.7
## PIEZO ALARM ASSEMBLY REPLACEMENT

The recommended tool for this procedure is a medium size flat blade screwdriver.

Replacement parts for this procedure are:

**Assembly, Piezo Alarm**
**Screw, 4-40 x 3/8, Hex Head, Slotted, with Washer**

To replace a piezo alarm assembly see *Figure 7-11 (2 of 2)*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.
3. Separate the front enclosure, rear enclosure, and main chassis assembly as described in *Section 7.2.6*.
4. Using the flat blade screwdriver, separate the upper and lower main chassis assemblies by removing the screws from the upper main chassis.
5. Expose the piezo alarm by lifting the upper main chassis. Place the chassis on the work surface.
6. Using the flat blade screwdriver, remove the screws that secure the piezo alarm to the lower main chassis assembly.
7. Disconnect the piezo alarm cable from the CPU PWA.

   **Note:** When installing, route the piezo alarm cable above the CPU/driver cable.

8. Install the replacement piezo alarm assembly in the exact reverse order of removal.
9. Join the front enclosure, rear enclosure, and main chassis assembly in the exact reverse order of separation.
10. Reinstall the batteries and connect the infuser to AC power.

To verify successful piezo alarm assembly replacement, perform the PVT in *Section 5.2*.

7.2.14.8

# MECHANISM ASSEMBLY REPLACEMENT

**Note:** Replacing the mechanism changes the biomed settings to those stored in the replacement mechanism assembly.

Recommended tools for this procedure are a medium size flat blade screwdriver and #2 Phillips screwdriver.

Replacement parts for this procedure are:

**Assembly, Mechanism**
**Bumper, Mechanism/Chassis**
**Screw, 6-32 x 1/2, Hex Head, Slotted, with Washer**

To replace a mechanism assembly see *Figure 7-11 (1 of 2)*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.
3. Separate the front enclosure, rear enclosure, and main chassis assembly as described in *Section 7.2.6*.
4. Disconnect the CPU/driver cable from the mechanism assembly.
5. Disconnect the motor power cable from the power supply PWA.
6. Using the flat blade screwdriver, separate the upper and lower main chassis assemblies by removing the screws from the upper main chassis.
7. Lift the upper main chassis assembly and place it on the work surface.
8. Using the flat blade screwdriver, remove the screw that secures the mechanism assembly to the upper main chassis assembly. Slide the mechanism assembly away from the main chassis assembly.
9. Disconnect the motor power cable from the mechanism assembly.
10. Inspect the mechanism/chassis bumpers and replace, if required.
11. Install the replacement mechanism assembly in the exact reverse order of removal.
12. Join the upper and lower main chassis assembly in the exact reverse order of separation.
13. Using fingers, tighten the remaining front screws.
14. Using the nutdriver, tighten the remaining front screws another 1/4 to 3/8 turn.
15. Join the front enclosure, rear enclosure, and main chassis assembly in the exact reverse order of separation.
16. Reinstall the batteries and connect the infuser to AC power.

To verify successful mechanism assembly replacement, perform the PVT in *Section 5.2*.

7.2.14.9

# CASSETTE DOOR AND FLUID SHIELD REPLACEMENT

The recommended tool for this procedure is a medium size flat blade screwdriver.

Replacement parts for this procedure are:

**Assembly, Cassette Door**
**Assembly, Fluid Shield**
**Cap, Door Pivot**
**Spring, Extension**
**Screw, 4-40 x 3/8, Hex Head, Slotted, with Washer**

To replace the cassette door and fluid shield see *Figure 7-14* and *Figure 7-15*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.
3. Separate the front enclosure, rear enclosure, and main chassis assembly as described in *Section 7.2.6*.
4. Remove the mechanism assembly as described in *Section 7.2.14.8*.
5. Using the flat blade screwdriver, remove the screw that secures the door pivot cap to the mechanism assembly.
6. Disengage the cassette door from the opener handle assembly and remove the door.
7. Disengage the clips on the back side of the fluid shield that retain the upper portion of the fluid shield to the mechanism assembly.
8. Lift the locking pins to release the fluid shield/driver flex connector, and disconnect the flex connector from the driver PWA.
9. Pull the shield away from the top of the mechanism assembly at an approximate 15 degree angle. Pull the shield up and away, clearing the mechanism assembly pins and plunger.
10. Align the mechanism assembly pins, then install the replacement fluid shield in the exact reverse order of removal.
11. Install the replacement cassette door in the exact reverse order of removal.
12. Replace the mechanism assembly in the exact reverse order of removal.
13. Join the front enclosure, rear enclosure, and main chassis assembly in the exact reverse order of separation.
14. Reinstall the batteries and connect the infuser to AC power.

To verify successful cassette door and fluid shield replacement, perform the PVT in *Section 5.2*.

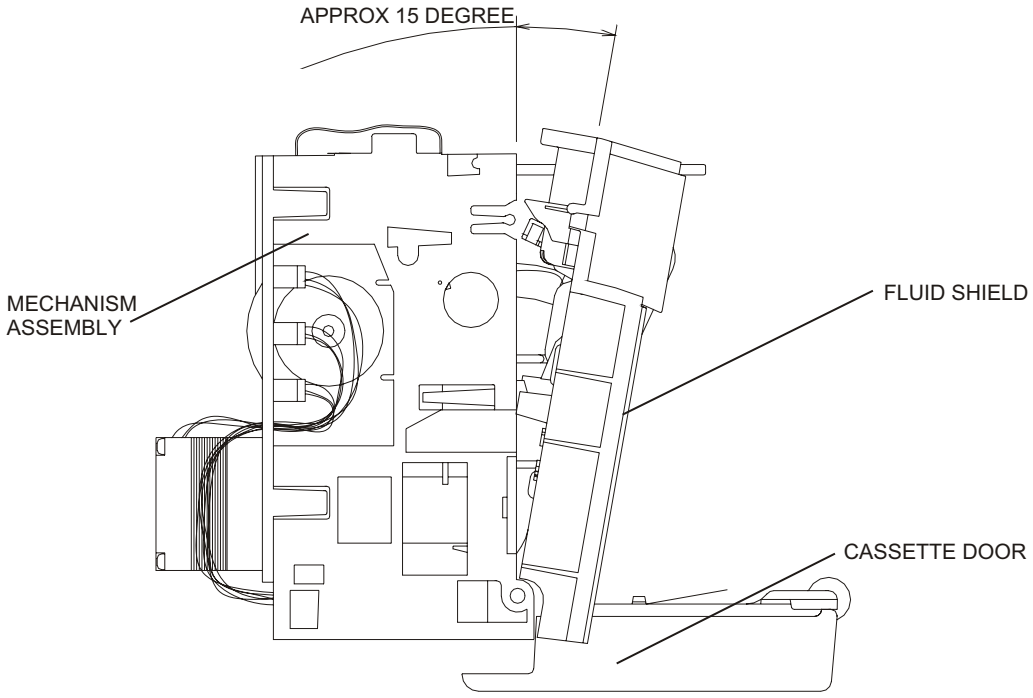



**Figure 7-14. Fluid Shield Replacement**

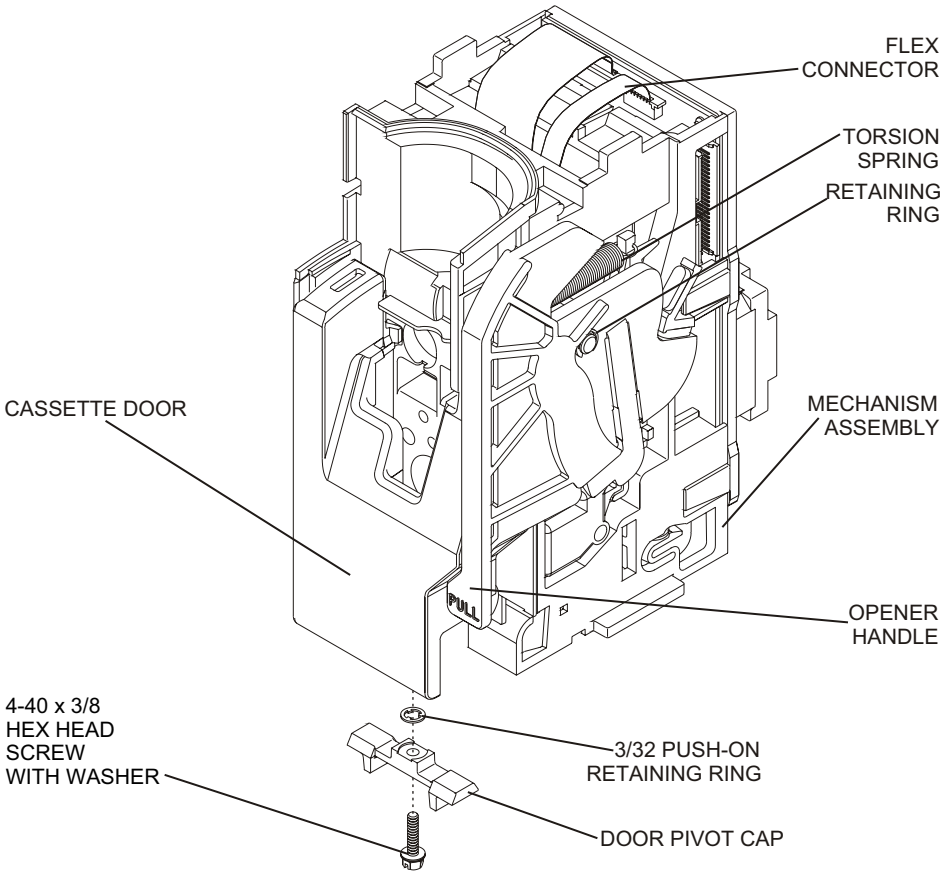



**Figure 7-15. Cassette Door and Opener Handle Assembly Replacement**

7.2.14.10

# OPENER HANDLE ASSEMBLY REPLACEMENT

The recommended tool for this procedure is a medium size flat blade screwdriver.

Replacement parts for this procedure are:

**Assembly, Opener Handle**
**Link, Door**
**Ring, Retaining, Push-On**

To replace the opener handle assembly see *Figure 7-15*, then proceed as follows:

1. Turn off the infuser, and disconnect the device from AC power.
2. Remove the batteries as described in *Section 7.2.4*.
3. Separate the front enclosure, rear enclosure, and main chassis assembly as described in *Section 7.2.6*.
4. Remove the mechanism assembly as described in *Section 7.2.14.8*.
5. Open the cassette door. Disengage and fully open the cassette door from the opener handle assembly.
6. Close the opener handle assembly.
7. Remove and inspect the retaining ring and replace, if required.
8. Remove and inspect the door link and replace, if required.
9. Insert the flat blade screwdriver between the opener handle assembly and the mechanism assembly. Carefully pry the assemblies apart.

   **Note:** The torsion spring may fall free.

10. Install the replacement opener handle assembly in the exact reverse order of removal. Confirm the opener handle is aligned properly.
11. Replace the mechanism assembly in the exact reverse order of removal.
12. Join the front enclosure, rear enclosure, and main chassis assembly in the exact reverse order of separation.
13. Reinstall the batteries and connect the infuser to AC power.

To verify successful opener handle assembly replacement, perform the PVT in *Section 5.2*.

## Section 8

# SPECIFICATIONS

The following specifications apply to the Plum A+3 infusion system.

**PHYSICAL**

**Dimensions:** Approximately 19 H x 15 W x 14 D inches (excluding pole clamp and power cord storage)

**Weight:** Approximately 28 lbs (with batteries)

**Casing:** High-impact plastic

**ELECTRICAL**

**Power Requirements:** 95-132 $V_{AC}$; 47-62 Hz; 90 W

**Power Cord:** Hospital-grade AC cord; 10 feet; with transparent plug and retainer plate

**Fuses:** 0.5 A, 250 $V_{AC}$

**Battery:** Three; sealed lead-acid; rechargeable; 6 V; internal

**Battery Operation:** A fully charged new battery provides approximately three hours of operation at 125 mL/hr or less, or delivers 250 mL if > 126 mL/hr.

Operation time is measured from initial pumping to the Depleted Battery alarm.

The infuser should be operated on battery power for three continuous hours every six months for optimum performance and battery life.

**Recharge:** The battery charges whenever the infuser is connected to AC power.

If the infuser is operating at 125 mL/hr on one line, a full recharge takes less than six hours.

**Self-Discharge:** 50 % of charge is retained for a minimum of one month when the infuser is not connected to AC power or is not operating.

**Nurse Call System:** Default: Normally open (NO)

Contact Hospira to make an internal adjustment to change the device from normally open (NO) to normally closed (NC).

**ENVIRONMENT**

**Operating:** 41° to 104° F (5° to 40° C); 10 % to 90 % relative humidity

**Transporting and Storage:** -4° to 140° F (-20° to 60° C); 10 % to 90 % relative humidity

**Atmospheric Pressure:** 0 - 10,000 feet (0 - 3000 meters)
or equivalent atmospheric pressure

**Relative Humidity:** 10 - 90 % (104° F max)

**DELIVERY RATE RANGE**

**Lines A and B:** 0.1 to 99.9 mL/hr (in 0.1 mL/hr increments)
100 to 999 mL/hr (in 1 mL/hr increments)

**Concurrent Delivery:** 0.5 mL/hr minimum for each line

**PlumSet:** 500 mL/hr cumulative (A+B) maximum

**KVO:** 1.0 mL/hr or the last primary delivery rate, whichever is less

**VTBI RANGE:** 0.1 to 99.9 mL (in 0.1 mL/hr increments)
100 to 9999 mL (in 1 mL/hr increments)

**OCCLUSION ALARM AND LIMITS**

**Distal:** The distal occlusion alarm sounds after the distal tubing or set outlet fitting becomes occluded.

**Proximal:** The proximal occlusion alarm sounds within two pumping cycles when the tubing proximal to the cassette becomes occluded.

**Distal Pressure Limit (Without Alarm):** 1 to 15 psi; maximum pressure limit is user-selectable; factory setting is 6 psi

**Maximum Infusion Pressure:** 20 psi

**AIR-IN-LINE ALARM**

**PlumSet (Distal):** Bolus: 0.5 mL of air or larger
Cumulative: 0.5 mL of air out of 5.3 mL of fluid

**PlumSet (Proximal):** Bolus at 0.5 mL, total 1.0 mL (0.5 mL concurrent)

# Section 9
# DRAWINGS

*Figure 9-1* through *Figure 9-10* show the Illustrated Parts Breakdown (IPB) and assembly drawings. *Table 9-1* lists drawings by figure number and title. *Table 9-2* identifies parts by index numbers which correlate to *Figure 9-1*.

Drawings in *Section 9* are provided as information only, and may not exactly reflect current product configuration.

**Table 9-1. Drawings**

| Figure Number | Title |
|---|---|
| 9-1 | Illustrated Parts Breakdown (2 sheets) |
| 9-2 | Front Enclosures, Rear Enclosure, and Main Chassis Assembly |
| 9-3 | Front Enclosure Assemblies |
| 9-4 | Rear Enclosure Assembly (2 sheets) |
| 9-5 | Peripheral Interface Assembly |
| 9-6 | Main Chassis Assembly (2 sheets) |
| 9-7 | CPU PWA, Display, and Keypad |
| 9-8 | CPU PWA and Main Chassis |
| 9-9 | AC Power Cord, Retainer, Batteries, and Minipole |
| 9-10 | Mechanism Assembly |

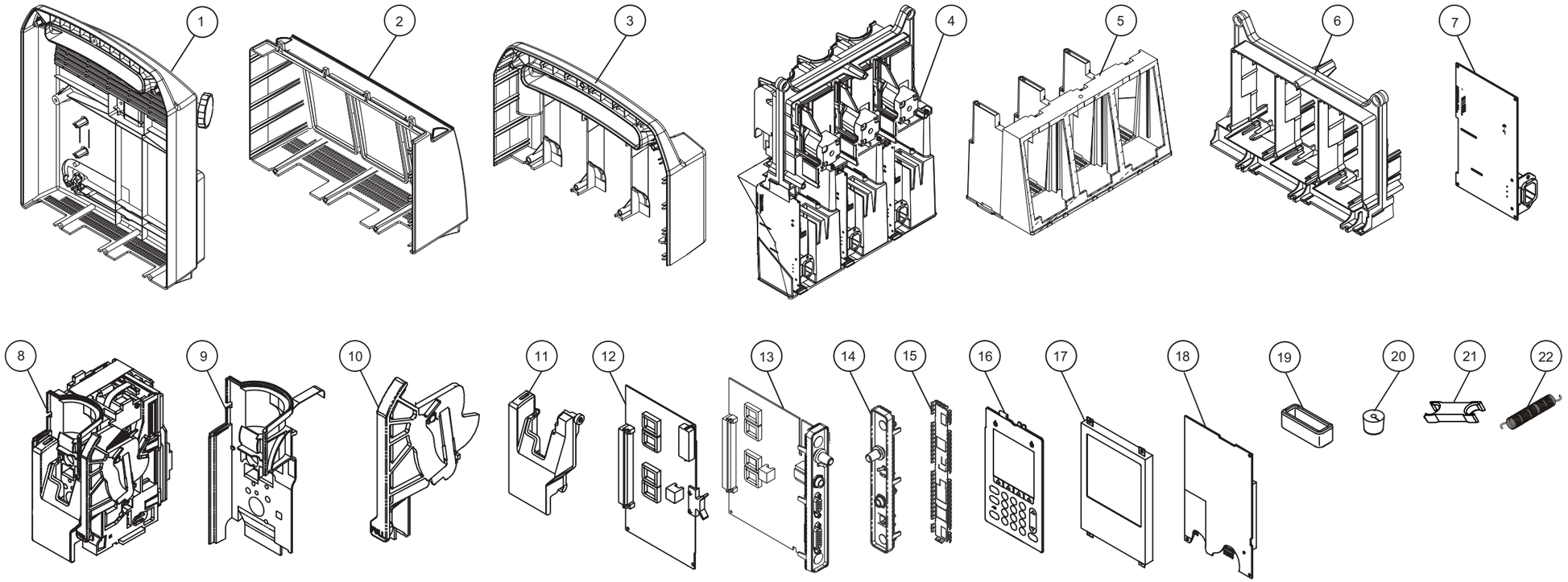
**Table 9-2. IPB for the Infuser**

| Index Number | Nomenclature | Replacement Procedure |
|---|---|---|
| 1 | Enclosure, Rear | *Section 7.2.6* |
| 2 | Enclosure, Lower Front | *Section 7.2.6* |
| 3 | Enclosure, Upper Front | *Section 7.2.6* |
| 4 | Assembly, Main Chassis | *Section 7.2.6* |
| 5 | Chassis, Lower | *Section 7.2.6* |
| 6 | Chassis, Upper | *Section 7.2.6* |
| 7 | PWA, Power Supply | *Section 7.2.14.1* |
| 8 | Assembly, Mechanism | *Section 7.2.14.8* |

| Table 9-2. IPB for the Infuser | | |
|---|---|---|
| **Index No.** | **Nomenclature** | **Replacement Procedure** |
| 9 | Assembly, Fluid Shield | *Section 7.2.14.9* |
| 10 | Assembly, Opener Handle | *Section 7.2.14.10* |
| 11 | Assembly, Cassette Door | *Section 7.2.14.9* |
| 12 | PWA, Peripheral | *Section 7.2.8* |
| 13 | Assembly, Peripheral Interface | *Section 7.2.7* |
| 14 | Cover, Peripheral | *Section 7.2.9.2* |
| 15 | Shield, Spring, ESD | *Section 7.2.9.2* |
| 16 | Assembly, Keypad | *Section 7.2.14.2* |
| 17 | Assembly, Display | *Section 7.2.14.3* |
| 18 | PWA, CPU | *Section 7.2.14.6* |
| 19 | Bumper, Mechanism/Chassis | *Section 7.2.14.8* |
| 20 | Pad, Rubber Foot | *Section 7.2.3* |
| 21 | Link, Door | *Section 7.2.14.10* |
| 22 | Spring, Extension | *Section 7.2.14.9* |
| 23 | Cordset, AC Power, Hospital Grade, Detachable | *Section 7.2.5* |
| 24 | Retainer, Power Cord | *Section 7.2.5* |
| 25 | Strap, Velcro, 1 3/4 in. x 10 in., Black | *Section 7.2.5* |
| 26 | Plate, Backing, Pole Clamp | *Section 7.2.12.1* |
| 27 | Assembly, Pole Clamp | *Section 7.2.12.1* |
| 28 | Wire, Ground, Pole Clamp | *Section 7.2.12.1* |
| 29 | Cord, AC Power, Internal | *Section 7.2.12.2* |
| 30 | Clamp, Internal AC Power Cord | *Section 7.2.12.2* |
| 31 | Assembly, Cable, Motor Power | *Section 7.2.14.5* |
| 32 | Assembly, Cable, Power Supply/Battery | *Section 7.2.14.1* |
| 33 | Wire, Ground, AC Power | *Section 7.2.12.2* |
| 34 | Assembly, Volume Control Knob, Gray | *Section 7.2.9.1* |
| 35 | Cap, Knob | *Section 7.2.9.1* |
| 36 | Cover, Knob | *Section 7.2.9.1* |

| Table 9-2. IPB for the Infuser | | |
|---|---|---|
| **Index No.** | **Nomenclature** | **Replacement Procedure** |
| 37 | Assembly, Minipole<br>A: Hanger, Bag<br>B: Housing, Clutch<br>C: Ring, Cotter<br>D: Spring, Clutch | *Section 7.2.13* |
| 38 | Assembly, Cable, Peripheral #2 | *Section 7.2.7* |
| 39 | Assembly, Cable, Peripheral #1 | *Section 7.2.7* |
| 40 | Assembly, Cable, CPU/Driver | *Section 7.2.14.4* |
| 41 | Assembly, Piezo Alarm | *Section 7.2.14.7* |
| 42 | Battery | *Section 7.2.4* |
| 43 | Assembly, Wire Harness, Battery | *Section 7.2.4* |
| 44 | Door, Battery | *Section 7.2.4* |
| 45 | Pad, Battery Door | *Section 7.2.4* |
| 46 | Tape, Insulation | *Section 7.2.14.4* |
| 47 | Tape, Ferrite | *Section 7.2.14.4* |
| 48 | Gasket, EMI, D-Shape, 6.62 in. | *Section 7.2.11.1* |
| 49 | Gasket, EMI, D-Shape, 13.0 in. | *Section 7.2.11.1* |
| 50 | Gasket, Front/Rear Enclosure | *Section 7.2.10* |
| 51 | Gasket, Rear Enclosure, 45 7/8 L | *Section 7.2.12.5* |
| 52 | Gasket, Rear Enclosure, 20 13/16 L | *Section 7.2.12.5* |
| 53 | Gasket, Keypad | *Section 7.2.11.2* |
| 54 | Gasket, Top Seal | *Section 7.2.11.3* |
| 55 | Cap, Door Pivot | *Section 7.2.14.9* |
| 56 | Connector, AC | *Section 7.2.12.3* |
| 57 | Drawer, Fuse | *Section 7.2.12.4* |
| 58 | Fuse, 1.6 A, 250 V | *Section 7.2.12.4* |
| 59 | Terminal, Equipotential | *Section 7.2.12.1* |
| 60 | Seal, Round | *Section 7.2.9.2* |
| 61 | Seal, Rectangle | *Section 7.2.9.2* |
| 62 | Mount, Cable Tie | *Section 7.2.11* |
| 63 | Tie, Cable | *Section 7.2.11* |
| 64 | Ring, Retaining, Push-On | *Section 7.2.4* |

| Table 9-2. IPB for the Infuser | | |
|---|---|---|
| **Index No.** | **Nomenclature** | **Replacement Procedure** |
| 65 | Screw, 4-24 x 1/4, Pan Head, Phillips, SS | As applicable |
| 66 | Screw, 4-40 x 1/4, Hex Head, Slotted, with Washer | As applicable |
| 67 | Screw, 4-40 x 3/8, Pan Head, Phillips, SS | As applicable |
| 68 | Screw, 4-40 x 3/8, Hex Head, Nylon | *Section 7.2.9.2* |
| 69 | Screw, 4-40 x 3/8, Hex Head, Slotted, with Washer | As applicable |
| 70 | Screw, 4-40 x 3/16, Hex Head, Slotted, with Washer | As applicable |
| 71 | Screw, 6-32 x 1/2, Pan Head, Phillips, SS | As applicable |
| 72 | Screw, 6-32 x 1 1/4, Pan Head, Phillips, SS | As applicable |
| 73 | Screw, 6-32 x 1/2, Hex Head, Slotted, with Washer | As applicable |
| 74 | Screw, 10-32 x 1/2, Hex Head, Slotted, with Washer | *Section 7.2.12.1* |
| 75 | Screw, 6-32 x 2 3/4, Pan Head, Phillips, SS | *Section 7.2.6* |
| 76 | Screw, 8-32 x 3 1/2, Pan Head, Phillips, SS | *Section 7.2.6* |
| 77 | Washer, Flat, 1/4, SS | As applicable |
| 78 | Washer, Flat, #6, SS | As applicable |
| 79 | Washer, Flat, #8, SS | As applicable |
| 80 | Washer, Flat, .128, Nylon | *Section 7.2.9.2* |
| 81 | Washer, Lock, Split, #6 | As applicable |
| 82 | Washer, Lock, 1/4, .025 Thk., Internal Tooth | As applicable |
| 83 | Nut, Hex, 4-40 | As applicable |
| 84 | Nut, Hex, 10 mm | *Section 7.2.12.1* |
| 85 | Nut, Hex, 6-32 | As applicable |
| 86 | Nut, Hex, Nurse Call Jack | *Section 7.2.9.2* |




| HOSPIRA, INC. | |
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| Figure 9-1.<br>Illustrated Parts Breakdown | |
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| | Sheet 1 of 2 |

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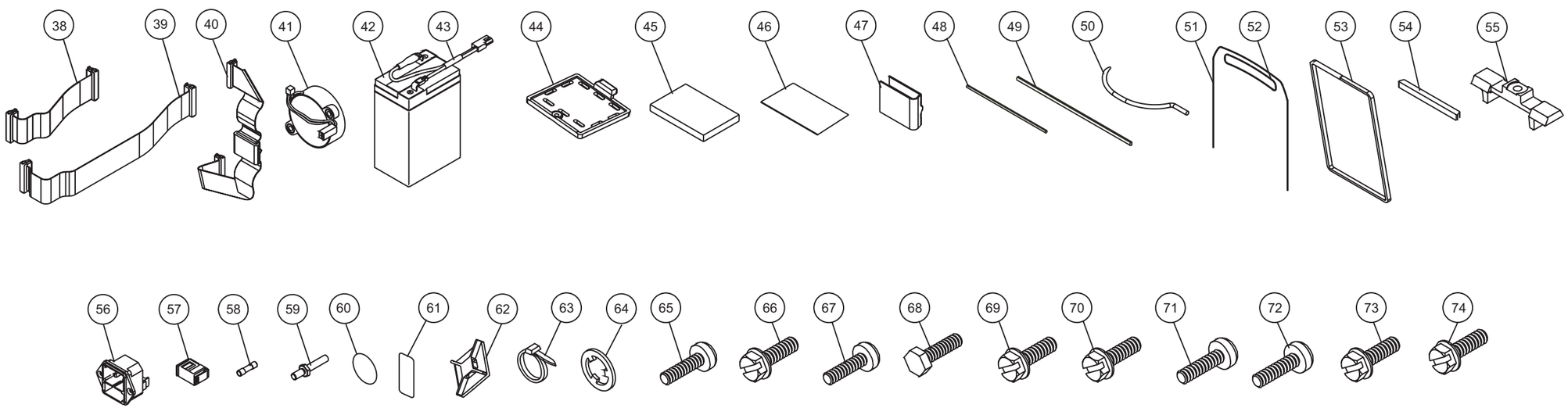


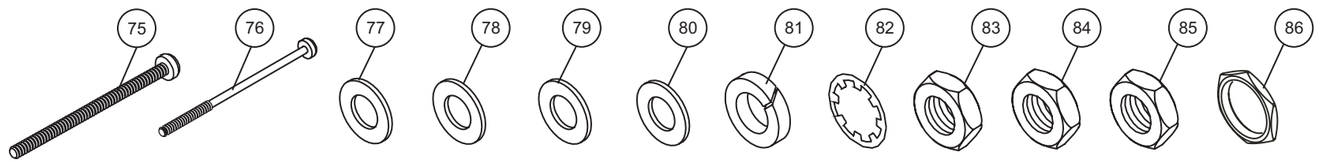


| HOSPIRA, INC. | |
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| Figure 9-1.<br>Illustrated Parts Breakdown | |
| DRAWING NO.<br>NOT APPLICABLE | Rev. N/A |
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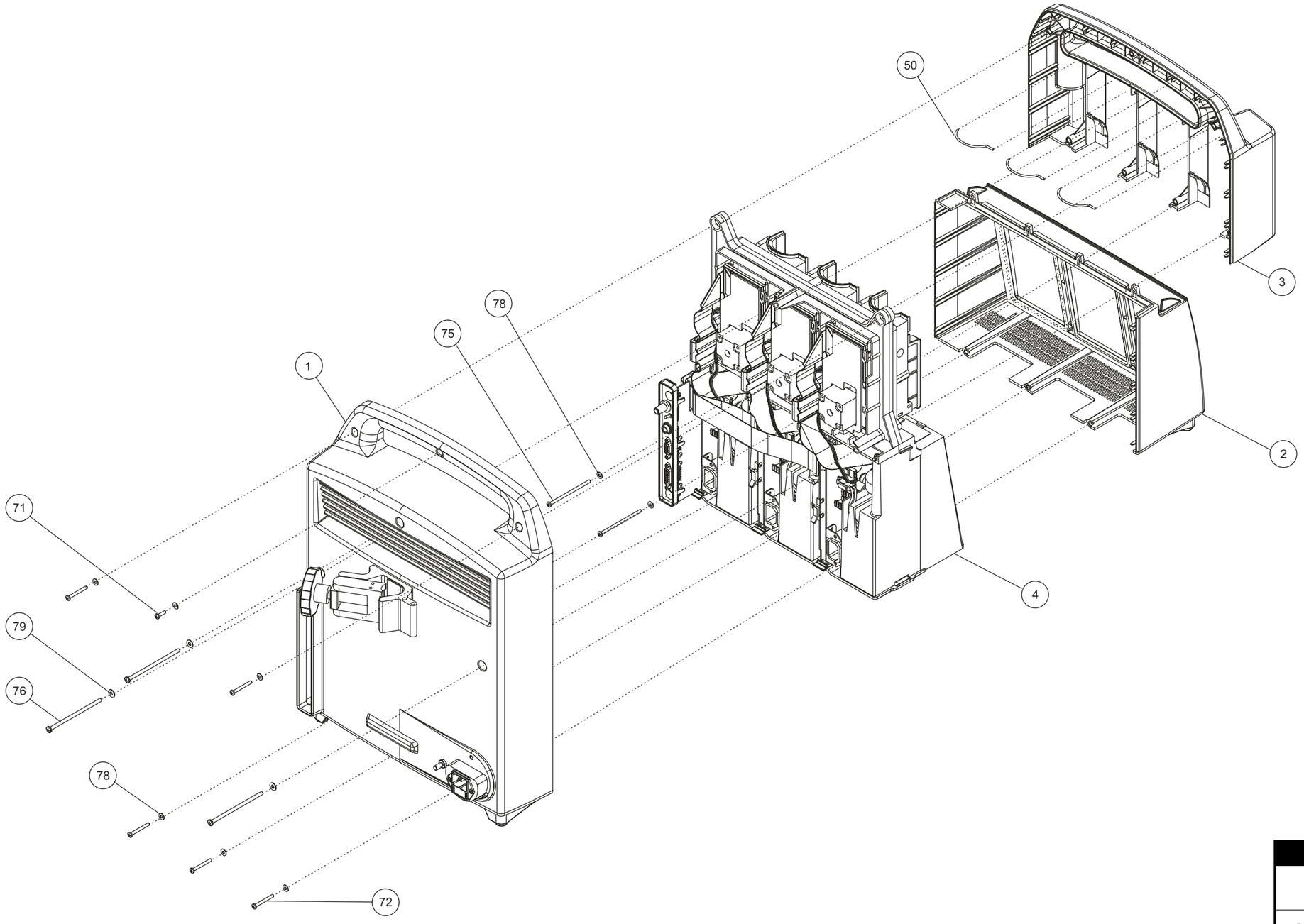


| HOSPIRA, INC. | |
|---|---|
| Figure 9-2.<br>Front Enclosures, Rear Enclosure,<br>and Main Chassis Assembly | |
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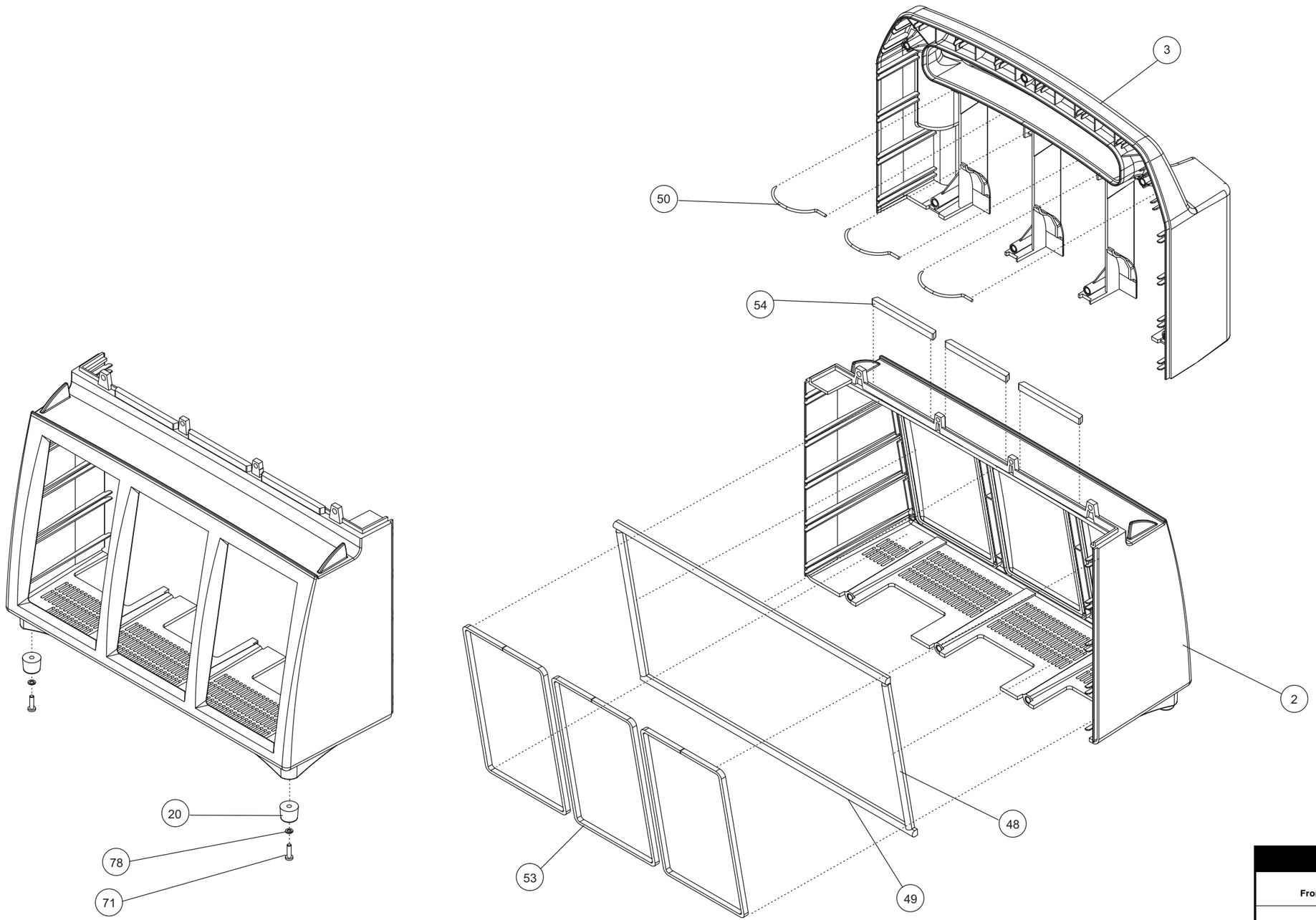


| HOSPIRA, INC. | |
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| Figure 9-3.<br>Front Enclosure Assemblies | |
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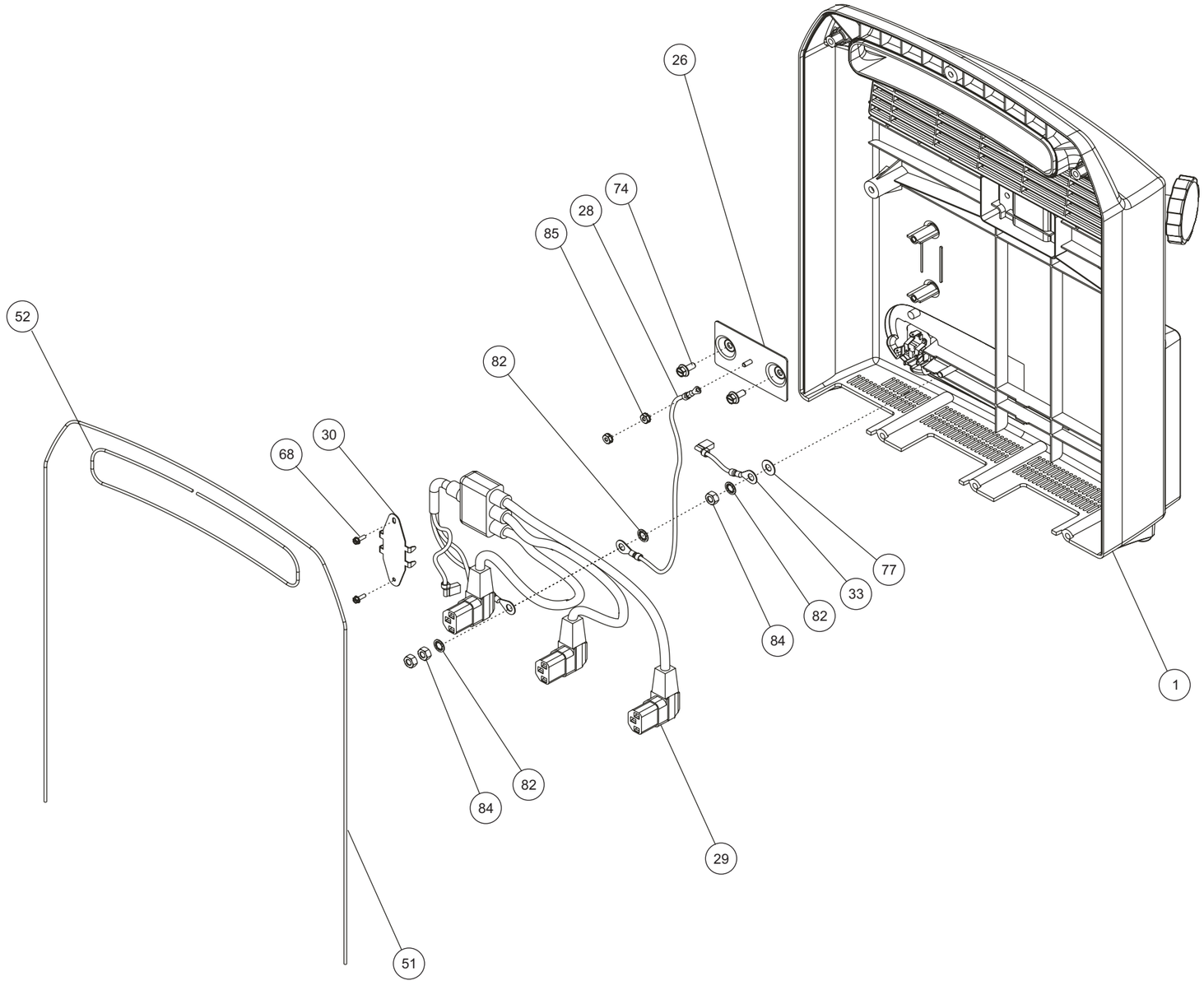


| HOSPIRA, INC. | |
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| Figure 9-4.<br>Rear Enclosure Assembly | |
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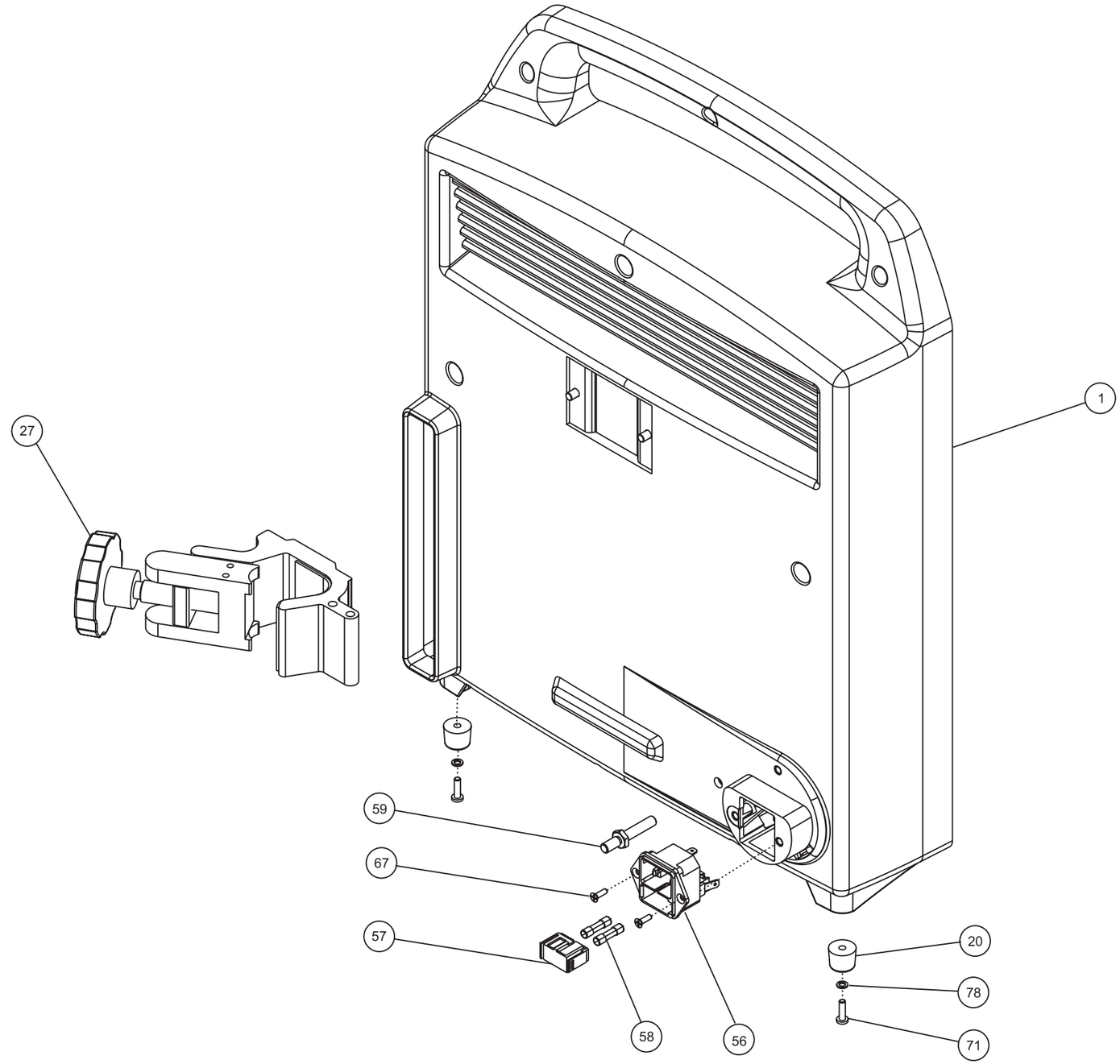


| HOSPIRA, INC. | |
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| Figure 9-4.<br>Rear Enclosure Assembly | |
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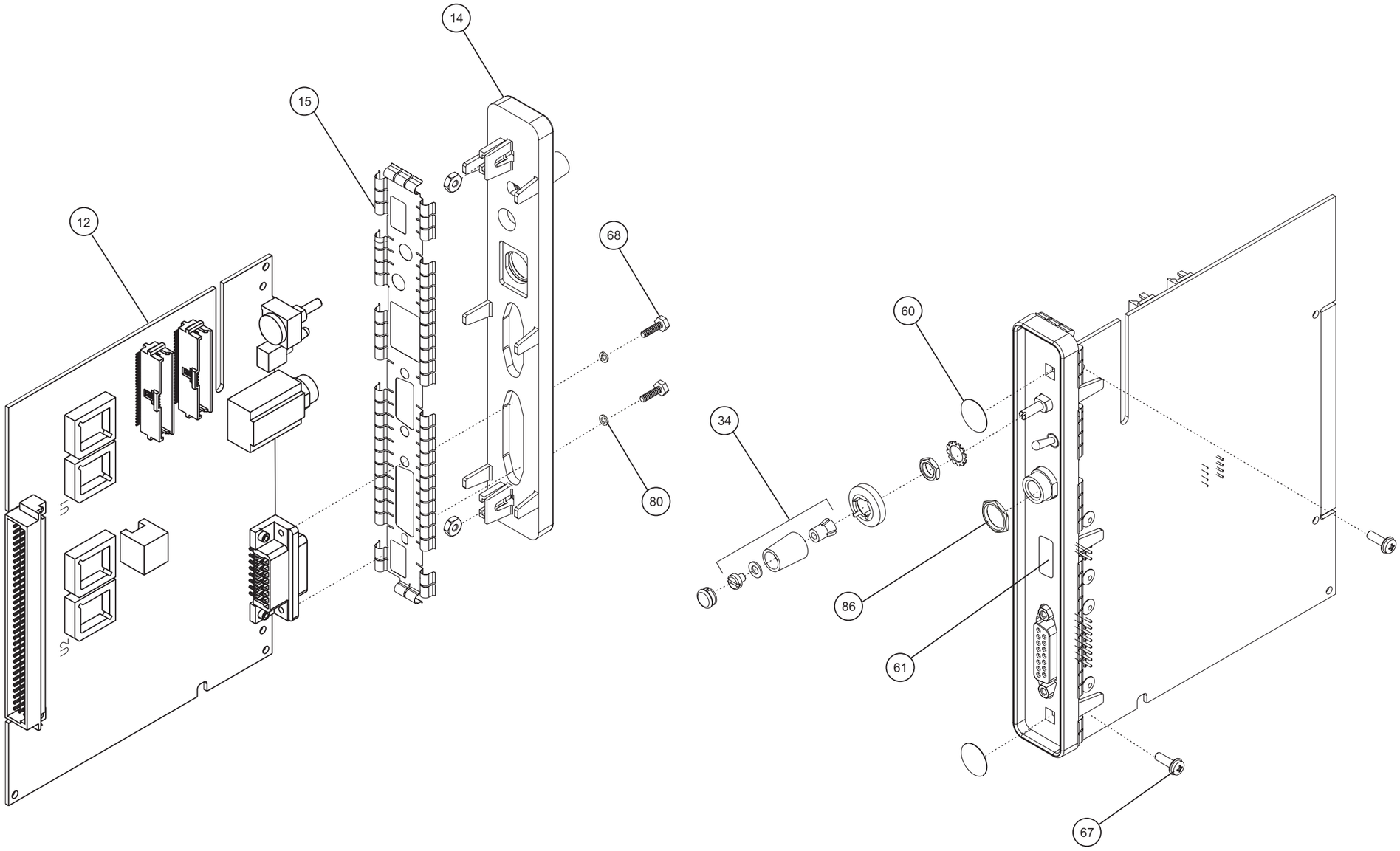


| HOSPIRA, INC. | |
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| Figure 9-5.<br>Peripheral Interface Assembly | |
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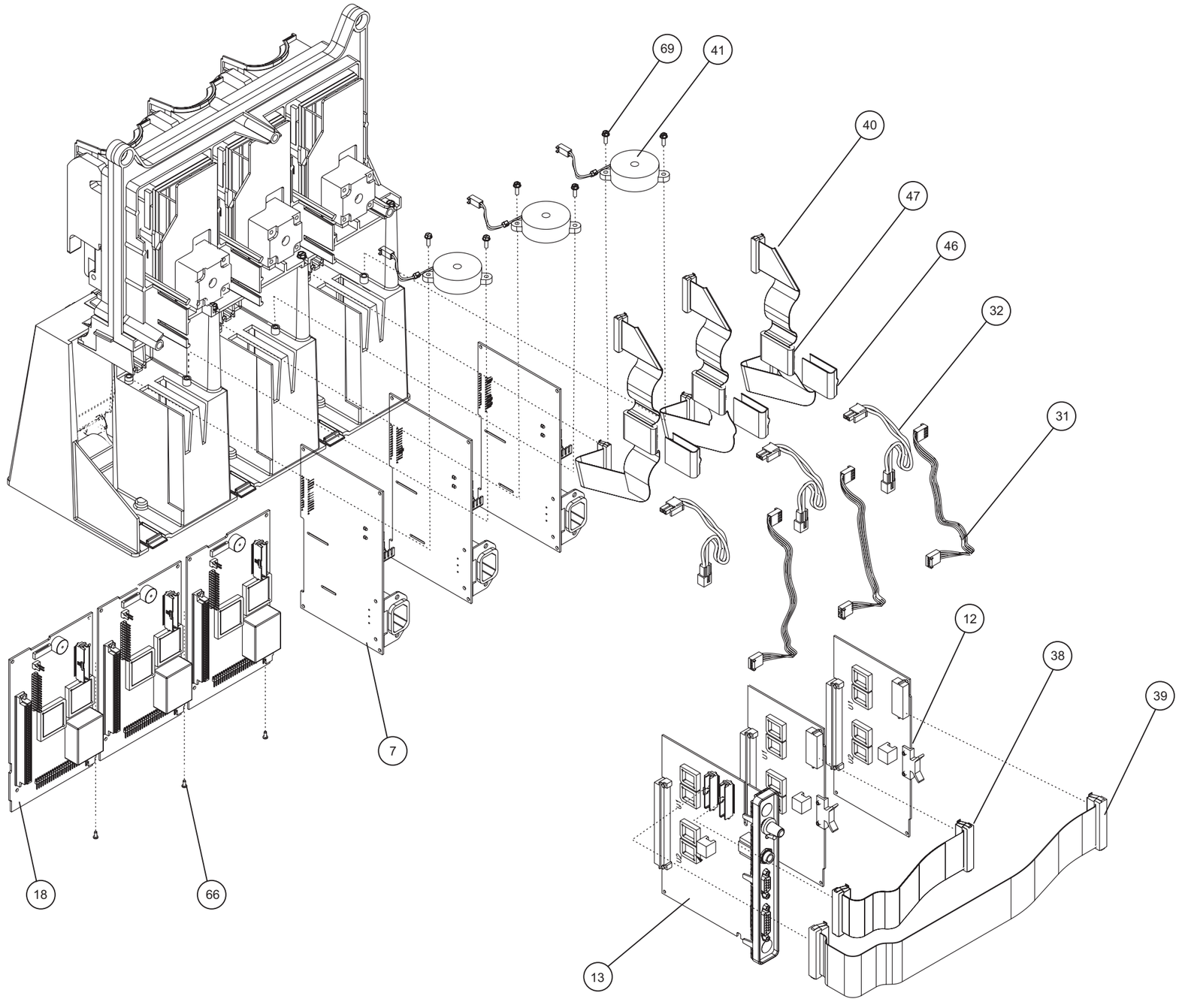


| HOSPIRA, INC. | |
|---|---|
| Figure 9-6.<br>Main Chassis Assembly | |
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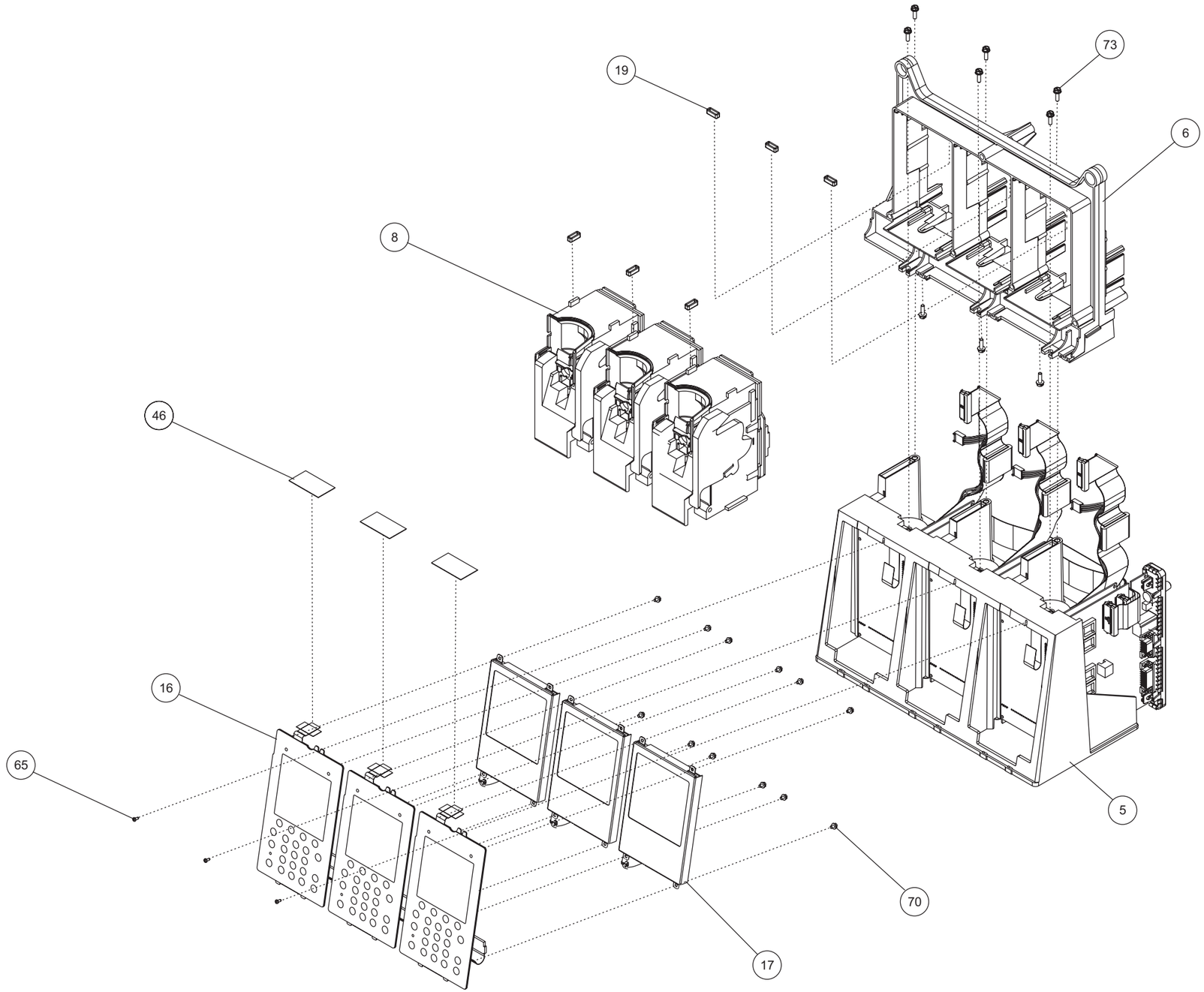


| HOSPIRA, INC. | |
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| Figure 9-6.<br>Main Chassis Assembly | |
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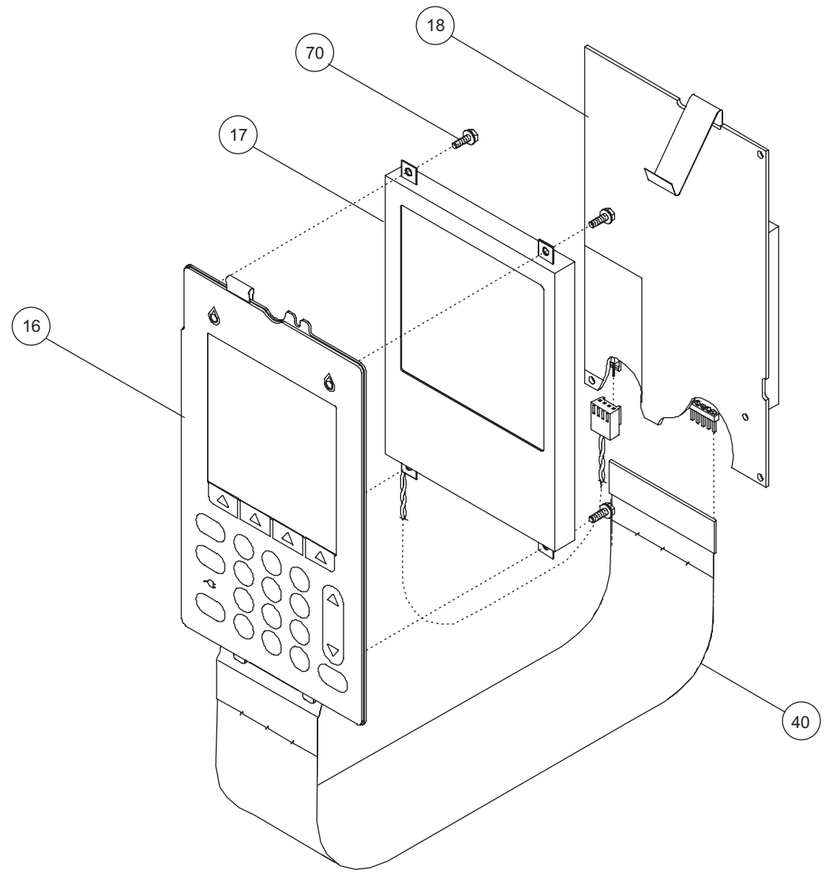


| HOSPIRA, INC. | |
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| Figure 9-7.<br>CPU PWA, Display, and Keypad | |
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| | Sheet 1 of 1 |

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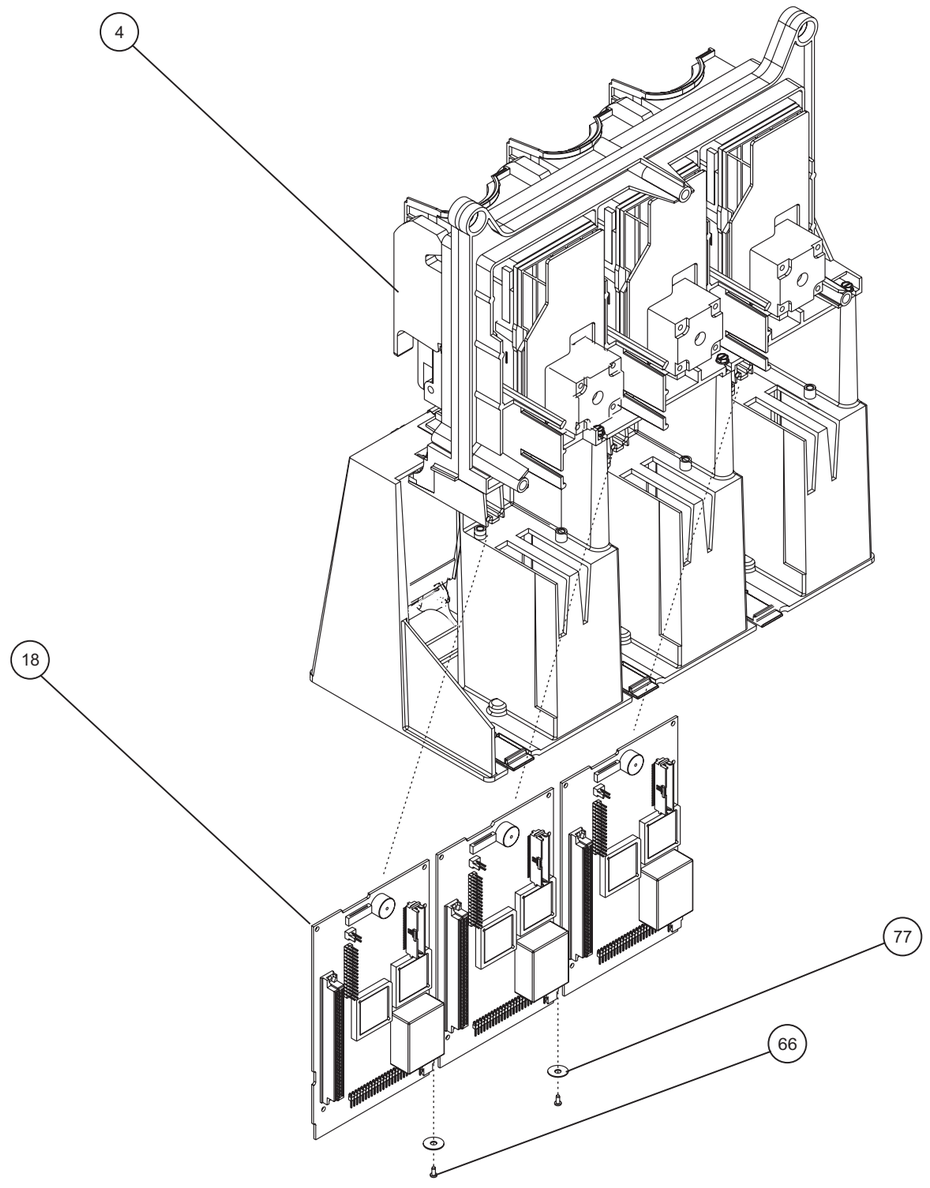


| HOSPIRA, INC. | |
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| Figure 9-8.<br>CPU PWA and Main Chassis | |
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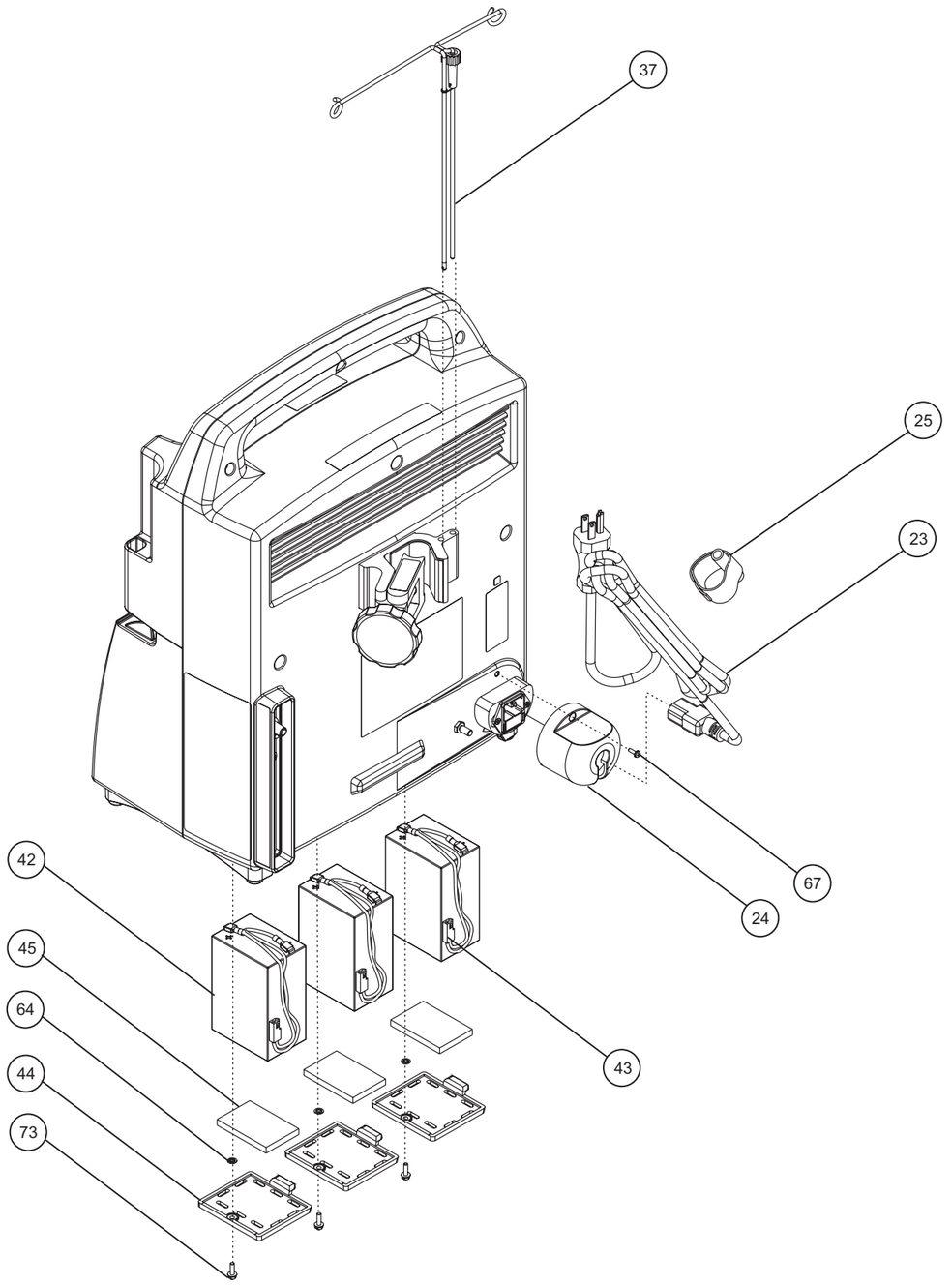


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| Figure 9-9.<br>AC Power Cord, Retainer, Batteries, and Minipole | |
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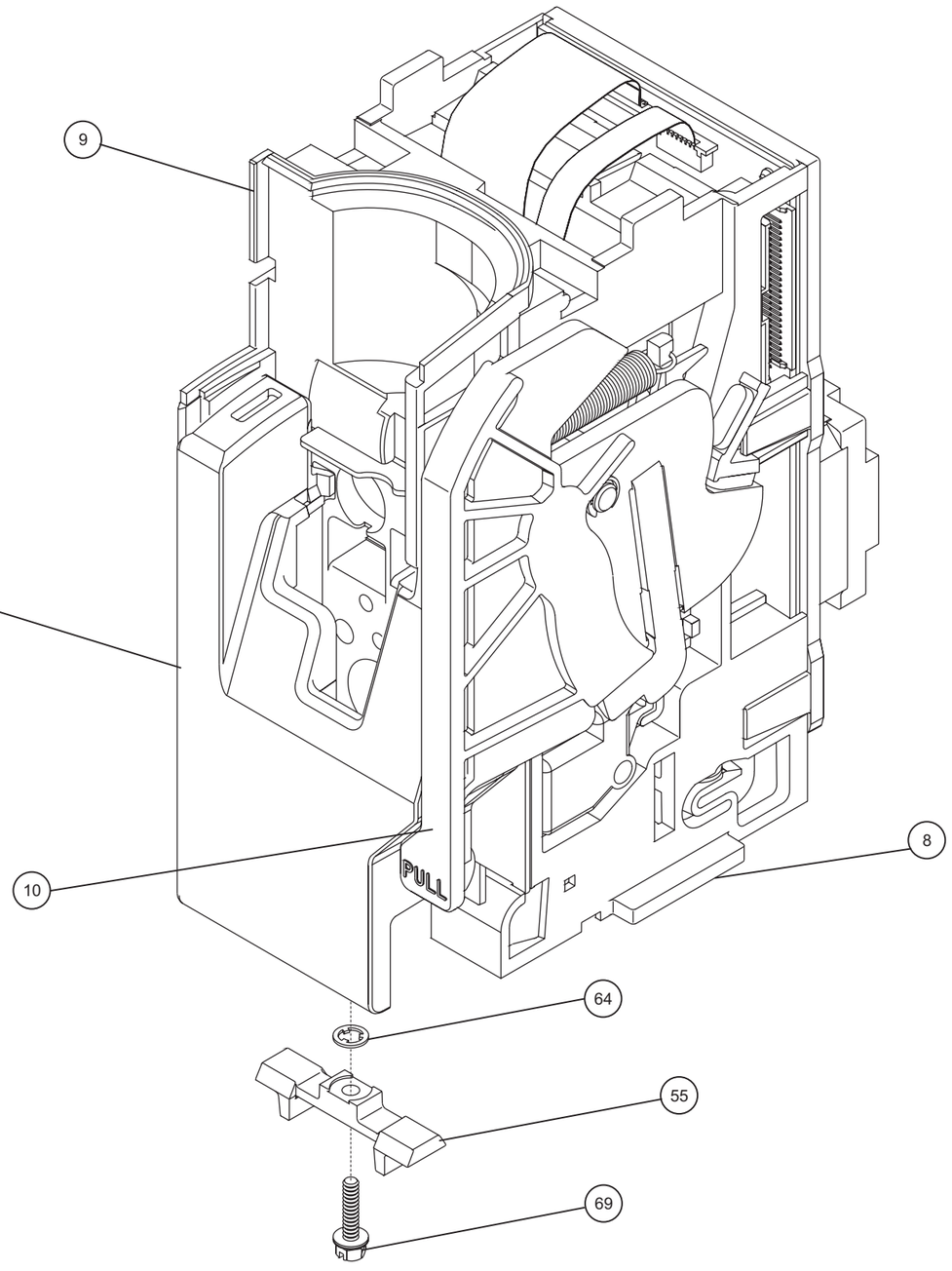


| HOSPIRA, INC. | |
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| Figure 9-10.<br>Mechanism Assembly | |
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| | Sheet 1 of 1 |

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# APPENDIX

## USE OF THE INFUSION SYSTEM IN ELECTROMAGNETIC ENVIRONMENTS

✓EN-2 The Plum A+3 Infusion System is intended for use in the electromagnetic environment specified in *Table A-1*, *Table A-2*, *Table A-3*, and *Table A-4*. The user of the infusion system should assure that it is used only in the appropriate environment.

## ELECTROMAGNETIC EMISSIONS

*Table A-1* details electromagnetic emissions compliance and guidance.

**Table A-1.**
**Guidance and Manufacturer's Declaration - Electromagnetic Emissions**

| Emissions Test | Compliance | Electromagnetic Enforcement - Guidance |
|---|---|---|
| RF Emissions<br>CISPR11 | Class B | The infuser is suitable for use in all establishments, including domestic establishments and those directly connected to the public low voltage power supply network that supplies buildings used for domestic purposes |
| Harmonic Emissions<br>IEC 61000-3-2 | Class B | |
| Voltage Fluctuations/ Flicker Emissions<br>IEC 61000-3-3 | Complies | |

# ELECTROMAGNETIC IMMUNITY

*Table A-2* details guidance for the electromagnetic environment.

**Table A-2.**
**Guidance and Manufacturer's Declaration - Electromagnetic Immunity**

| Immunity Test | IEC 60601 Test Level | Compliance Level | Electromagnetic Environment Guidance |
|---|---|---|---|
| Electrostatic Discharge (ESD)<br>IEC 61000-4-2 | ±6 kV Contact<br>±8 kV Air | ±8 kV Contact<br>±15 kV Air | Floors should be wood, concrete, or ceramic tile<br>If floors are covered with synthetic material, relative humidity should be at least 30% |
| Electrical Fast Transient/Burst<br>IEC 61000-4-4 | ±2 kV for power supply lines<br>±1 kV for input/output lines | ±2 kV for power supply lines<br>±1 kV for input/output lines | Mains power quality should be that of a typical commercial or hospital environment |
| Surge<br>IEC 61000-4-5 | ±1 kV differential mode<br>±2 kV common mode | ±1 kV differential mode<br>±2 kV common mode | |
| Voltage Dips, Short Interruptions, and Voltage Variations on Power Supply Input Lines<br>IEC 61000-4-11 | <5% $U_r$ (>95% dip in $U_r$) for 0.5 cycle<br>40% $U_r$ (60% dip in $U_r$) for 5 cycles<br>70% $U_r$ (30% dip in $U_r$) for 25 cycles<br>5% $U_r$ (>95% dip in $U_r$) for 5 seconds | <5% $U_r$ (>95% dip in $U_r$) for 0.5 cycle<br>40% $U_r$ (60% dip in $U_r$) for 5 cycles<br>70% $U_r$ (30% dip in $U_r$) for 25 cycles<br>5% $U_r$ (>95% dip in $U_r$) for 5 seconds | Mains power quality should be that of a typical commercial or hospital environment<br>If the user of the infusion system requires continued operation during power mains interruptions, it is recommended that the infuser be powered from an uninterruptible AC mains power supply or the battery |
| Power Frequency (50/60 Hz) Magnetic Field<br>IEC 61000-4-8 | 3 A/m | 400 A/m | Power frequency magnetic fields should be at levels characteristic of a typical location in a typical commercial or hospital environment |

$U_r$ is the AC Mains voltage prior to application of the test level.

Compliance levels are tested to IEC 60601-2-24 requirements, which are more stringent than IEC 61000-4-2 and IEC 61000-4-8.

# ELECTROMAGNETIC IMMUNITY FOR LIFE-SUPPORTING EQUIPMENT AND SYSTEMS

*Table A-3* provides guidance for use of the infusion system near communications equipment.

**Table A-3.**
**Guidance and Manufacturer's Declaration -**
**Electromagnetic Immunity for Life-Supporting Equipment and Systems**

| Immunity Test | IEC 60601 Test Level | Compliance Level | Electromagnetic Immunity Guidance |
|---|---|---|---|
| | | | Portable and mobile RF communications equipment should be used no closer to any part of the infusion system, including cables, than the recommended separation distance calculated from the equation applicable to the frequency of the transmitter |
| Conducted RF<br>IEC 61000-4-6 | 3 $V_{rms}$<br>150 kHz to 80 MHz outside ISM bands[a] | [$V_1$] V | Recommended separation distance<br>$d = \left[\frac{3,5}{V_1}\right]\sqrt{P}$<br>$d = \left[\frac{12}{V_2}\right]\sqrt{P}$ |
| | 10 $V_{rms}$<br>150 kHz to 80 MHz in ISM bands[a] | [$V_2$] V | |
| Radiated RF<br>IEC 61000-4-3 | 10 V/m<br>80 MHZ to 2.5 GHz | [$E_1$] V/m | Recommended separation distance:<br>$d = \left[\frac{12}{E_1}\right]\sqrt{P}$ 80 MHz to 800 MHz<br>$d = \left[\frac{23}{E_1}\right]\sqrt{P}$ 800 MHz to 2.5 GHz<br>Where *P* is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer and *d* is the recommended separation distance in meters (m)[b]<br>Field strengths from fixed RF transmitters, as determined by an electromagnetic site survey,[c] should be less than the compliance level in each frequency range[d]<br>Interference may occur in the vicinity of equipment marked with the following symbol |

**Note:** These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.

At 80 MHz and 800 MHz, the higher frequency range applies.

[a] The industrial, scientific and medical (ISM) bands between 150 kHz and 80 MHz are 6.765 MHz to 6.795 MHz; 13.553 MHz to 13.567 MHz; 26.957 MHz to 27.283 MHz; and 40.660 MHz to 40.700 MHz.

[b] The compliance levels in the ISM frequency bands between 150 kHz and 80 MHz and in the frequency range 80 MHz to 2.5 GHz are intended to decrease the likelihood that mobile/portable communications equipment could cause interference if it is inadvertently brought into patient areas. For this reason, an additional factor of 10/3 is used in calculating the recommended separation distance for transmitters in these frequency ranges.

[c] Field strengths from fixed transmitters, such as base stations for radio (cellular and/or cordless) telephones and land mobile radios, amateur radio, AM and FM radio broadcast and TV broadcast cannot be predicted theoretically with accuracy. To assess the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location in which the infuser is used exceeds the applicable RF compliance level above, the infuser should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as re-orienting or relocating the infuser.

[d] Over the frequency range 150 kHz to 80 MHz, field strengths should be less than $[V_1]$ V/m.

# RECOMMENDED SEPARATION DISTANCES FOR COMMUNICATIONS EQUIPMENT

The infusion system is intended for use in an electromagnetic environment in which radiated RF disturbances are controlled. The recommendations provided in *Table A-4* help the user of the infusion system to prevent electromagnetic interference by maintaining a minimum distance between portable and mobile RF communications equipment (transmitters) and the infuser, according to the maximum output power of the communications equipment.

**Table A-4.**
**Recommended Separation Distances Between Portable and Mobile RF Communications Equipment and the Infusion System**

| Rated Maximum Output Power of Transmitter (Watts) | Separation Distance According to Frequency of Transmitter (Meters) | | | |
|---|---|---|---|---|
| | 150 kHz to 80 MHZ outside ISM bands $d = \left[\frac{3,5}{V_1}\right]\sqrt{P}$ | 150 kHz to 80 MHz in ISM bands $d = \left[\frac{12}{V_2}\right]\sqrt{P}$ | 80 Mhz to 800 MHz $d = \left[\frac{12}{E_1}\right]\sqrt{P}$ | 800 MHz to 2.5 GHz $d = \left[\frac{23}{E_1}\right]\sqrt{P}$ |
| 0.01 | 0.035 | 0.12 | 0.12 | 0.23 |
| 0.1 | 0.11 | 0.38 | 0.38 | 0.73 |
| 1 | 0.35 | 1.2 | 1.2 | 2.3 |
| 10 | 1.1 | 3.8 | 3.8 | 7.3 |
| 100 | 3.5 | 12 | 12 | 23 |
| For transmitters rated at a maximum output power not listed above, the recommended separation distance *d* in meters (m) can be determined using the equation applicable to the frequency of the transmitter, where *P* is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer. | | | | |

**Note:** These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structure, objects and people.

At 80 MHz and 800 MHz, the separation distance for the higher frequency range applies.

The ISM bands between 150 kHz and 80 MHz are 6.765 MHz to 6.695 MHz; 13.553 MHz to 13.567 MHz; 26.957 MHz to 27.283 MHz; and 40.660 MHz to 40.700 MHz.

An additional factor of 10/3 is used in calculating the recommended separation distance for transmitters in the ISM frequency bands between 150 kHz and 80 MHz and in the frequency range 80 MHz to 2.5 GHz to decrease the likelihood that mobile/portable communications equipment could cause interference if it is inadvertently brought into patient areas.

$V_1$=10 $V_{rms}$, $V_2$=10 $V_{rms}$, and $E_1$=10 V/meter

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# INDEX

## A


A/B valve subsystem, 4-30
AC connector replacement, 7-21
AC power cord
    Replacement, 7-6
    Retainer, 7-6
    Velcro strap, 7-6
Acronyms and abbreviations, 1-3
Air sensors, 4-19
    Receiver circuitry, 4-20
    Transmitter circuitry, 4-19
Alarm loudness test, 5-8
Alarm messages and error codes, 6-2
    Error codes requiring technical service, 6-7
    Operational alarm messages, 6-2
Alarms log, 1-12
Analog-to-digital converter, 4-6
APP PWA, 4-26
Artifacts, 1-5
Audible indicators, 4-9
Auxiliary supplies, 4-14


## B


Barcode reader
    Interface, 4-9
    Wand, 4-27
Battery
    Charger, 4-16
    Door, 7-3
    Door pad, 7-3
    Operation overview, 5-16
    Replacement, 7-3
    Voltage measurement, 4-15
    Wire harness, 7-3
Battery charge/discharge current measurement, 4-15
Biomed settings, 1-8
    Alarms log, 1-12
    IV parameters, 1-10
    Setting the time and date, 1-13


## C


Cassette, 4-28
    Alarm test, 5-6
Cassette door replacement, 7-35
Cassette type/presence selection, 4-22
Cleaning and sanitizing, 5-1
    Cleaning solutions, 5-2
Component designators, 1-2
Contact Hospira, 6-1
Control logic, 4-4
Conventions, 1-2
CPU, 4-3
CPU PWA, 4-25
    Replacement, 7-32
CPU subsystem, 4-3
    Analog-to-digital converter, 4-6
    Audible indicators, 4-9
    Barcode reader interface, 4-9
    Control logic, 4-4
    CPU, 4-3
    DataPort interface, 4-10
    Digital-to-analog converter, 4-8
    Front panel
        Keypad matrix, 4-8
        LED indicators, 4-8
        On/off key, 4-8
    LCD
        Backlight control, 4-5
        Contrast control, 4-5
        Controller, 4-4
    Keypad lockout interface, 4-8
    Mechanism interface, 4-11
    Nurse call interface, 4-9
    Power supply interface, 4-10
    Programmable read-only memory, 4-4
    Real-time clock, 4-5
    Static random access memory, 4-4
    System memory address map, 4-3
    Voltage monitor watchdog timer, 4-6
CPU/driver cable replacement, 7-29

## D

DataPort interface, 4-10
Delivery accuracy test, 5-13
Digital-to-analog converter, 4-8
Display assembly replacement, 7-28
Display test, 5-6
Distal air-in-line test, 5-11
Distal occlusion test, 5-11
Drawings, 9-1
Driver PWA, 4-25

## E

Electrical safety test, 5-14
    Electrical safety measurements, 5-14
Electronic subsystem overview, 4-2
    CPU subsystem, 4-3
    Mechanism subsystem, 4-16
    Power supply subsystem, 4-13
EMI gasket replacement, 7-16
End of the PVT, 5-15
Equipment required, 5-3
Error codes requiring
  technical service, 6-7

## F

Fluid shield replacement, 7-35
Free flow test, 5-6
Front panel
    Keypad matrix, 4-8
    LED indicators, 4-8
    On/off key, 4-8
Front/rear enclosure gasket
  replacement, 7-15
Fuse replacement, 7-22

## G

Gaskets
    EMI, 7-16
    Front/rear enclosure, 7-15
    Keypad, 7-17
    Lower front enclosure, 7-15
    Rear enclosure, 7-23
    Top seal, 7-17
General description, 4-1

## I

Illustrated parts breakdown, 9-1
Inlet/outlet valve subsystem, 4-31
Inspection, 1-6, 5-3
Instrument installation procedure, 1-5
    Inspection, 1-6
    Self test, 1-6
    Unpacking, 1-6
Internal AC power cord replacement, 7-21
Introduction, 1-1
    Acronyms and abbreviations, 1-3
    Artifacts, 1-5
    Biomed settings, 1-8
    Component designators, 1-2
    Conventions, 1-2
    Instrument installation procedure, 1-5
    Scope, 1-1
    User qualification, 1-5
IV parameters, 1-10

## K

Keypad
    Gasket, 7-17
    Lockout interface, 4-8
    Replacement, 7-27
Keypad verification/functional test, 5-7

## L

LCD, 4-27
    Backlight control, 4-5
    Contrast control, 4-5
    Controller, 4-4
Lockout switch test, 5-9
Lower front enclosure gasket
  replacement, 7-15

## M

Main chassis assembly component
  replacement, 7-24
Main regulator fault detection, 4-14
Main switching regulator, 4-13
    Current limit loop, 4-14
    Main loop, 4-13
    Secondary loop, 4-13

Maintenance and service tests, 5-1
Battery operation overview, 5-16
Performance verification test, 5-2
Periodic maintenance inspection, 5-15
Routine maintenance, 5-1
Mechanical overview, 4-27
Cassette, 4-28
Mechanism assembly, 4-30
Mechanism assembly, 4-30
A/B valve subsystem, 4-30
Inlet/outlet valve subsystem, 4-31
Motor and valve assemblies, 4-30
Plunger drive subsystem, 4-31
Replacement, 7-34
Mechanism interface, 4-11
Mechanism subsystem, 4-16
Air sensors, 4-19
Cassette type/presence selection, 4-22
Motor position sensors, 4-18
Motors/motor drive, 4-16
Pressure sensor calibration, 4-22
Pressure sensors, 4-20
Serial EEPROM, 4-22
V2_5 reference voltage, 4-18
Minipole assembly replacement, 7-23
Motor and valve assemblies, 4-30
Motor position sensors, 4-18
Motor power cable replacement, 7-32
Motors/motor drive, 4-16
Chopper motor drive, 4-17
Stepper motors, 4-17

## N

Nurse call
Interface, 4-9
Test, 5-14

## O

Opener handle assembly replacement, 7-38
Operational alarm messages, 6-2

## P

Performance verification test, 5-2
Alarm loudness test, 5-8
Cassette alarm test, 5-6
Delivery accuracy test, 5-13
Display test, 5-6
Distal air-in-line test, 5-11
Distal occlusion test, 5-11
Electrical safety test, 5-14
End of the PVT, 5-15
Equipment required, 5-3
Free flow test, 5-6
Inspection, 5-3
Keypad verification/functional test, 5-7
Lockout switch test, 5-9
Nurse call test, 5-14
Proximal air-in-line test, 5-10
Proximal occlusion test, 5-9
Self test, 5-4
Test setup, 5-4
Periodic maintenance inspection, 5-15
Peripheral component replacement, 7-11
Peripheral cover, 7-12
Volume control knob, 7-12
Peripheral cover replacement, 7-12
Peripheral interface assembly replacement, 7-9
Peripheral interface PWA, 4-24
Peripheral PWA, 4-24
Replacement, 7-10
Piezo alarm assembly replacement, 7-33
Plunger drive subsystem, 4-31
Pole clamp assembly replacement, 7-20
Backing plate, 7-20
Power control, 4-14
Power supply interface, 4-10
Power supply PWA, 4-23
Replacement, 7-27
Power supply subsystem, 4-13
Auxiliary supplies, 4-14
Battery charge/discharge current measurement, 4-15
Battery charger, 4-16
Battery voltage measurement, 4-15
Main regulator fault detection, 4-14
Main switching regulator, 4-13
Power control, 4-14
System power, 4-14

Pressure sensor calibration, 4-22
Pressure sensors, 4-20
  Amplifier and low pass filter, 4-21
  Bridge excitation supply, 4-21
Printed wiring assemblies, 4-23
  APP, 4-26
  CPU, 4-25
  Driver, 4-25
  Peripheral, 4-24
  Peripheral interface, 4-24
  Power supply, 4-23
  Switch, 4-26
Programmable read-only memory, 4-4
Proximal air-in-line test, 5-10
Proximal occlusion test, 5-9

## R

Real-time clock, 4-5
Rear enclosure assembly component replacement, 7-18
Rear enclosure gasket replacement, 7-23
Remote mounted peripherals, 4-27
  Barcode reader wand, 4-27
  LCD, 4-27
  Sealed lead acid battery, 4-27
Replaceable parts and repairs, 7-1
Replacement procedures, 7-1
  AC connector, 7-21
  AC power cord, retainer, and Velcro strap, 7-6
  Battery, wire harness, door, and door pad, 7-3
  Cassette door, 7-35
  CPU PWA, 7-32
  CPU/driver cable, 7-29
  Display assembly, 7-28
  EMI gasket, 7-16
  Fluid shield, 7-35
  Front/rear enclosure gasket, 7-15
  Fuse, 7-22
  Internal AC power cord, 7-21
  Keypad, 7-27
  Keypad gasket, 7-17
  Lower front enclosure gasket, 7-15
  Main chassis assembly components, 7-24
  Mechanism assembly, 7-34
  Minipole assembly, 7-23
  Motor power cable, 7-32
  Opener handle assembly, 7-38
  Peripheral components, 7-11
  Peripheral cover, 7-12
  Peripheral interface assembly, 7-9
  Peripheral PWA, 7-10
  Piezo alarm assembly, 7-33
  Pole clamp assembly and backing plate, 7-20
  Power supply PWA, 7-27
  Rear enclosure assembly components, 7-18
  Rear enclosure gasket, 7-23
  Required tools and materials, 7-2
  Rubber foot pad, 7-2
  Safety and equipment precautions, 7-1
  Separating the front enclosure, rear enclosure, and main chassis assembly, 7-7
  Top seal gasket, 7-17
  Volume control knob, 7-12
Required tools and materials, 7-2
Routine maintenance, 5-1
  Cleaning and sanitizing, 5-1
Rubber foot pad replacement, 7-2

## S

Safety and equipment precautions, 7-1
Scope, 1-1
Sealed lead acid battery, 4-27
Self test, 1-6, 5-4
Separating the front enclosure, rear enclosure, and main chassis assembly, 7-7
Serial EEPROM, 4-22
Setting the time and date, 1-13
Specifications, 8-1
Static random access memory, 4-4
Switch PWA, 4-26
System memory address map, 4-3
System operating manual, 3-1
System power, 4-14

## T

Technical assistance, 6-1
Test setup, 5-4
Theory of operation, 4-1
  Electronic subsystem overview, 4-2
  General description, 4-1
  Mechanical overview, 4-27
  Printed wiring assemblies, 4-23
  Remote mounted peripherals, 4-27

Top seal gasket replacement, 7-17
Troubleshooting, 6-1
    Alarm messages and error codes, 6-2
    Procedures, 6-11
    Technical assistance, 6-1
    Warning messages, 6-1

## U

Unpacking, 1-6
User qualification, 1-5

## V

V2_5 reference voltage, 4-18
Velcro strap replacement, 7-6
Voltage monitor watchdog timer, 4-6
Volume control knob replacement, 7-12

## W

Warning messages, 6-1
Warranty, 2-1

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